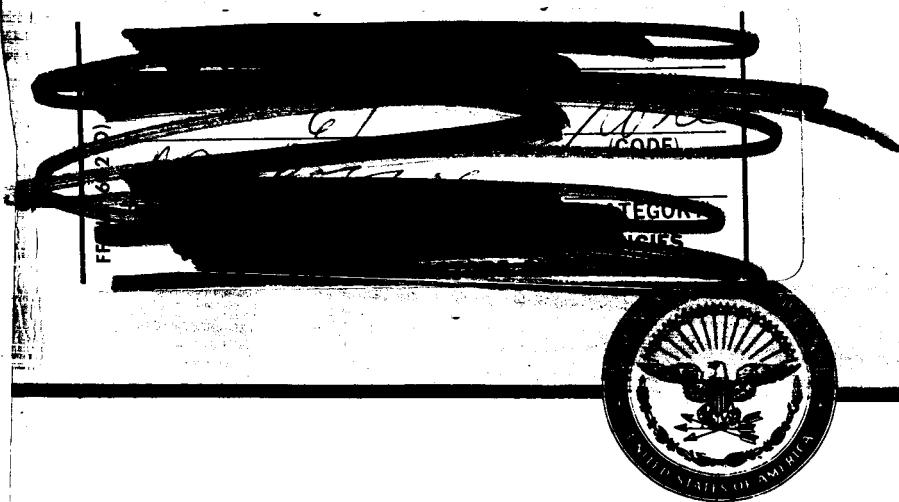


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DISTRIBUTION OF AERODYNAMIC LOADS ON THE
PROJECT MERCURY VEHICLE (U) (S)

[U]

⑩ by R. H. Adams

⑪ 17 August 1959,

APR 7 1963

APPROVED:

J. R. Sellars

⑤

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Page 1

DISTRIBUTION OF AERODYNAMIC LOADS ON THE
PROJECT MERCURY VEHICLE

Wind tunnel tests were conducted for ~~McDonnell Aircraft~~ by the NASA at their Ames Unitary Plan Wind Tunnel on a 7% scale model of Project Mercury. These tests provided force data, reported in References (1) and (2), and surface pressure data, presented herein.

Two configurations were tested. One consisted of the ATLAS booster and the MIS capsule; the other consisted of the ATLAS booster and the MIS capsule and escape tower with rocket. The escape rocket, tower and capsule are shown in Figure 1 mounted in position on the ATLAS booster.

Zero angle of attack pressure distributions for Mach numbers of $M = 1.55, 2.00, 2.30, 3.02$, and 3.49 on the capsule without tower are shown in Figures 2 and 3. Comparable pressure distributions for the vehicle with tower are shown in Figures 4 through 8. Note that the tower-off plots are presented as single test points and the tower-on plots are presented as a band of data. Test data revealed that with the tower off, at $\alpha = 0^\circ$, the circumferential variation of the pressure coefficient, C_p , at a particular axial station was within experimental error (within $C_p = \pm .02$). However, the tower-on data showed a random circumferential variation of the pressure coefficient within the bands shown in Figures 4 through 8, evidently due to the high degree of turbulence caused by the tower. Another notable effect on the $\alpha = 0^\circ$ pressure distribution, caused by the presence of the tower, is the increase of C_p at station 366 along with a decrease of C_p at station 370. That is, with the tower off a peak pressure, quite normal for supersonic flow, occurs on the face of the step at station 370. With the tower on, a peak pressure occurs 4 inches

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Page 2

ahead of the step at station 366 and the pressure coefficient on the face is very nearly zero. Shadowgraphs revealed a high degree of subsonic turbulence in this region. Shifting of the peak C_p is evidently due to the feedback of pressure through this subsonic layer. The zero angle of attack pressure distributions over the escape rocket (essentially a spiked cylinder with a flange) are shown in Figure 9.

The circumferential distributions of pressure coefficients for various axial stations on the capsule are shown in Figures 10 through 27 for the vehicle without the tower at $M = 1.55$ (approximately maximum dynamic pressure) and $\alpha = 2^\circ, 4.1^\circ, 6.1^\circ$. The corresponding plots for the tower-on configuration for various axial stations on the escape rocket and the capsule are shown in Figures 28 through 57.

Integrating the circumferential pressure distributions led to the normal force distributions shown in Figures 58 through 60. Comparison of Figures 58 and 59 (the tower-off and tower-on configurations, respectively) reveals that there is a higher degree of linearity of normal force for the tower-on configuration than there is for the tower-off configuration, particularly on the cone frustum of the capsule (station 380 to 450). This effect is attributed to the fact that for the tower-on configuration the capsule is immersed in a turbulent wake which is relatively unaffected by angle of attack whereas without the tower the blunt nose and step of the capsule are directly exposed to the airstream, no doubt resulting in separation and vorticity effects downstream. The normal force distribution over the escape rocket is shown in Figure 60 to be fairly linear. Note that the total normal force (obtained by integrating under the curves) of Figure 58 and the total normal force of Figures 59 and 60 are approximately equal as was revealed in the normal force data of the force tests reported in Reference (2).

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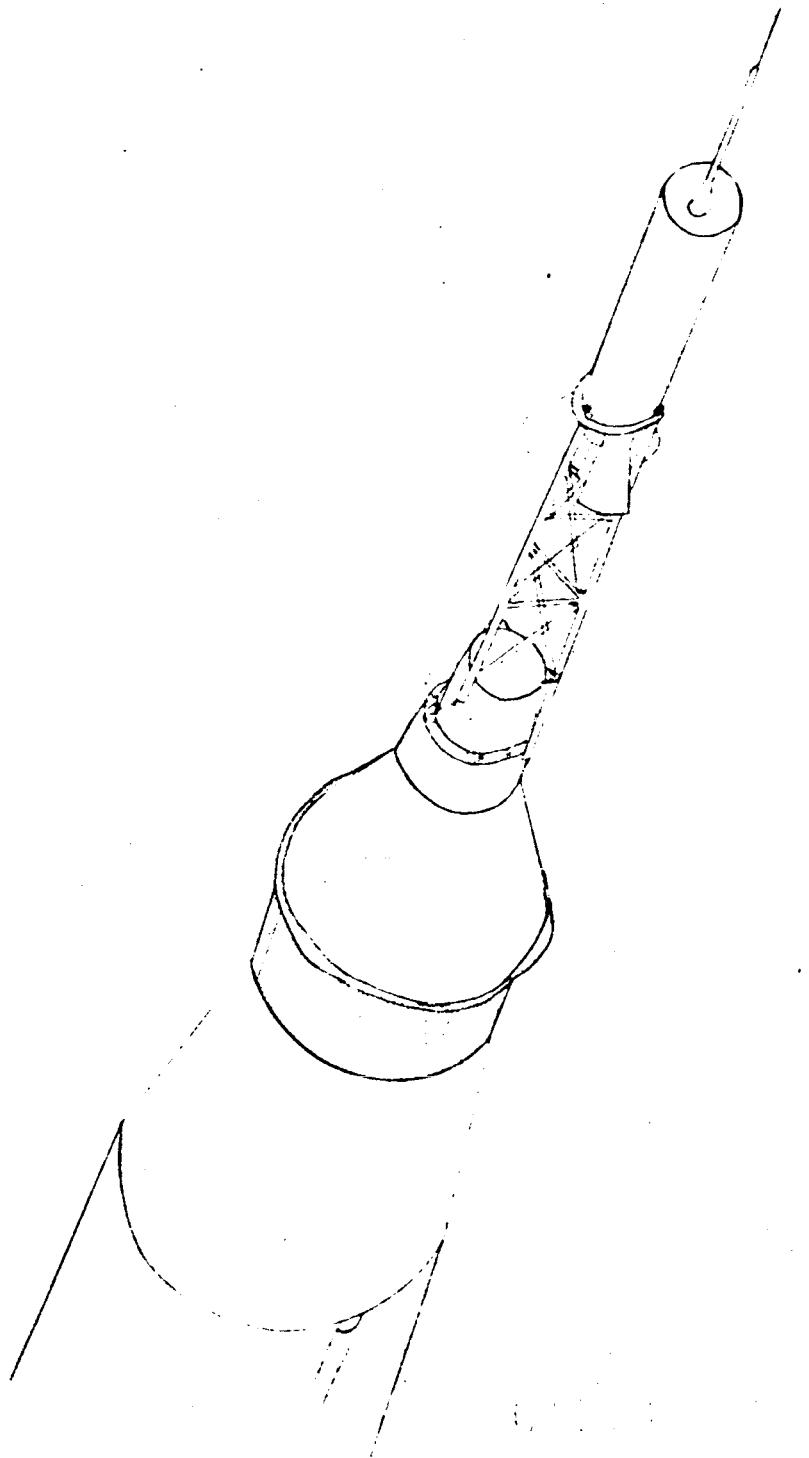
REFERENCES:

- (1) GM-59-7540-59; "Measured Aerodynamic Force Characteristics on Project Mercury - Addendum I," R. H. Adams to D. C. Bakeman, 21 May 1959 - Confidential
- (2) GM-59-7540.3-59; "Measured Aerodynamic Force Characteristics on Project Mercury - Addendum II," R. H. Adams to D. C Bakeman, 3 June 1959 - Confidential

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ESCAPE ROCKET, TOWER AND MIS CAPSULE
MOUNTED ON THE ATLAS BOOSTER

Figure 1

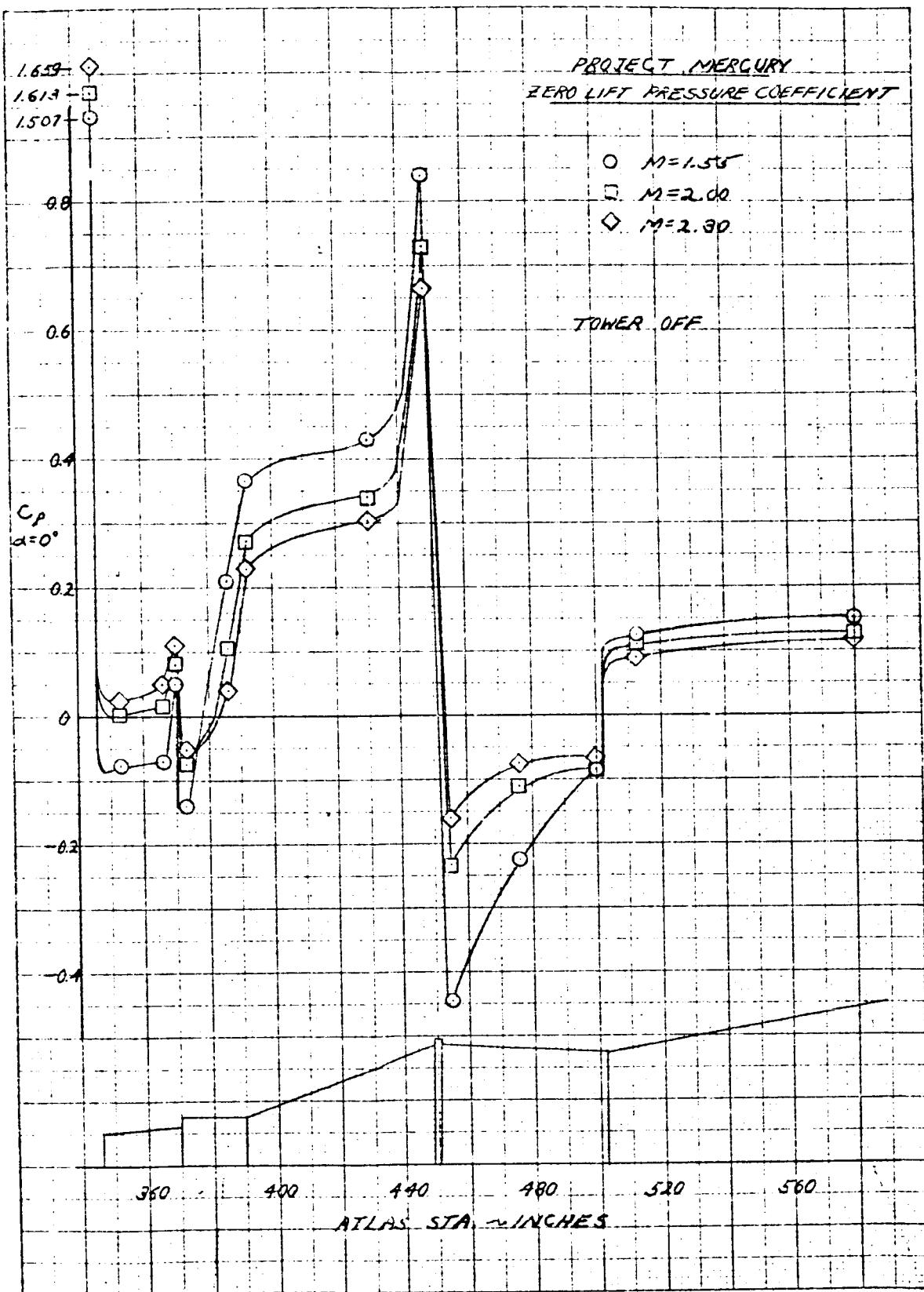


Figure 2

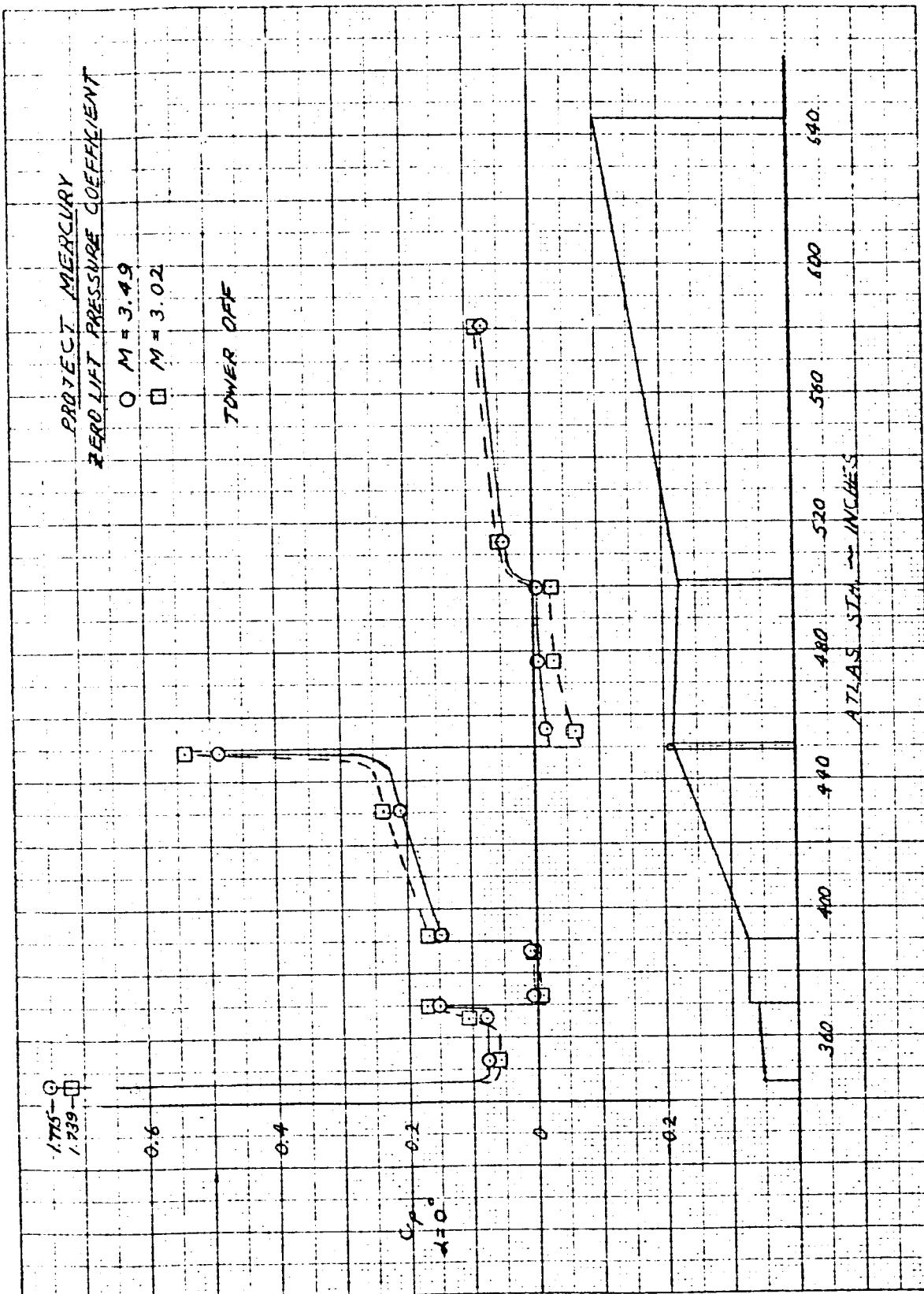


Figure 3

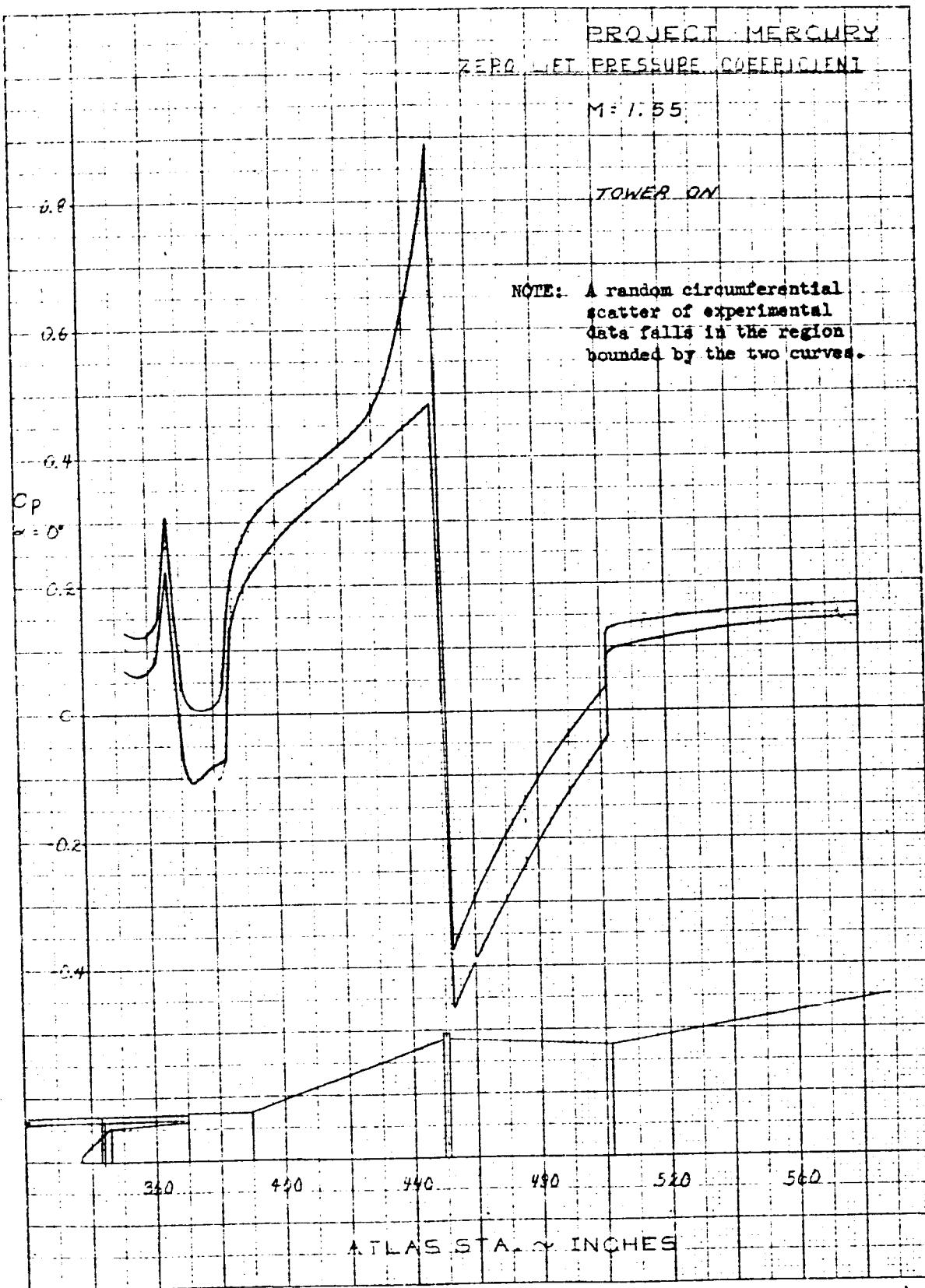


Figure 4

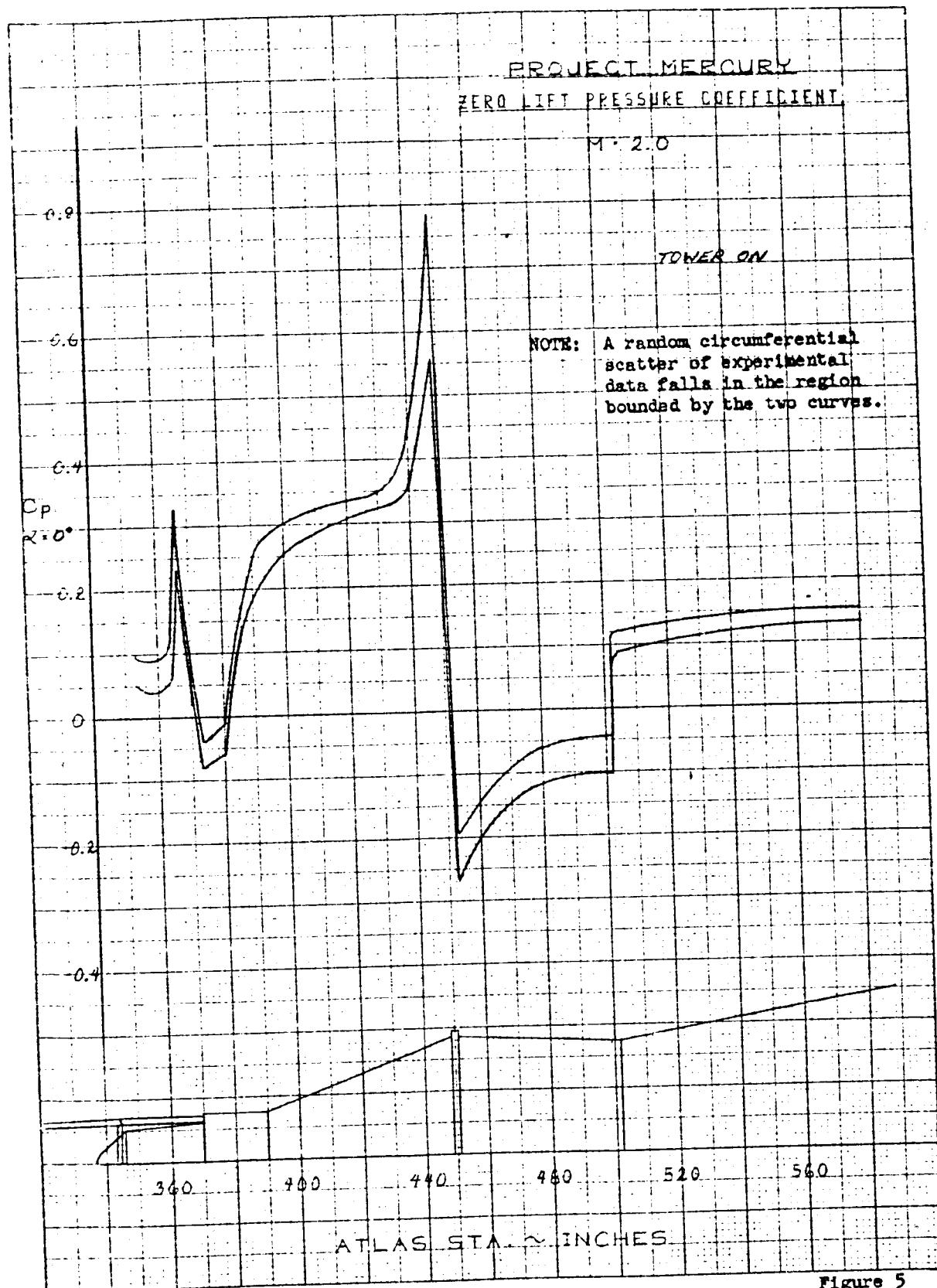
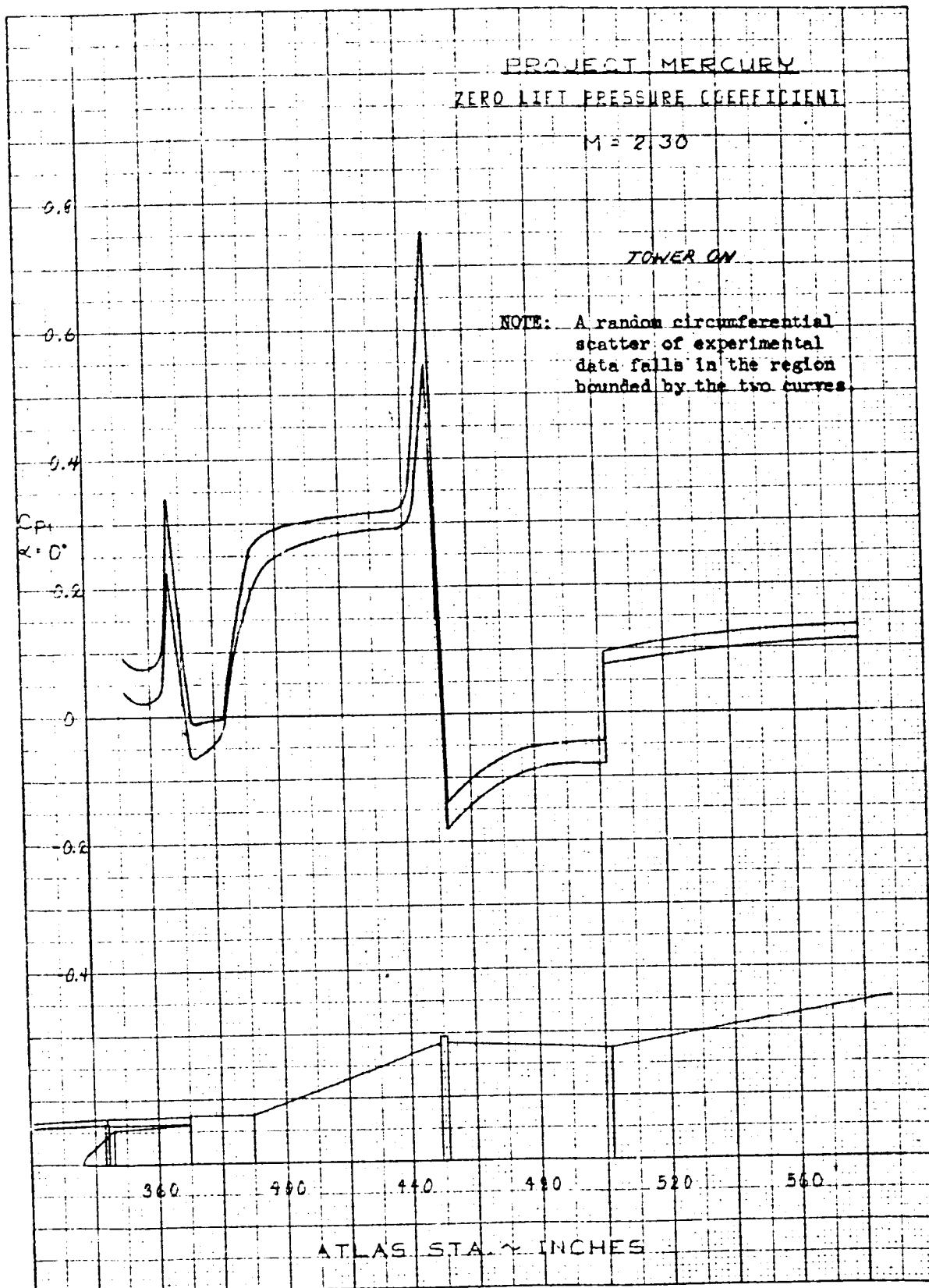


Figure 5



SCALE 10X10 TO THE INCH
FLUID DENSITY 359.11

Figure 6

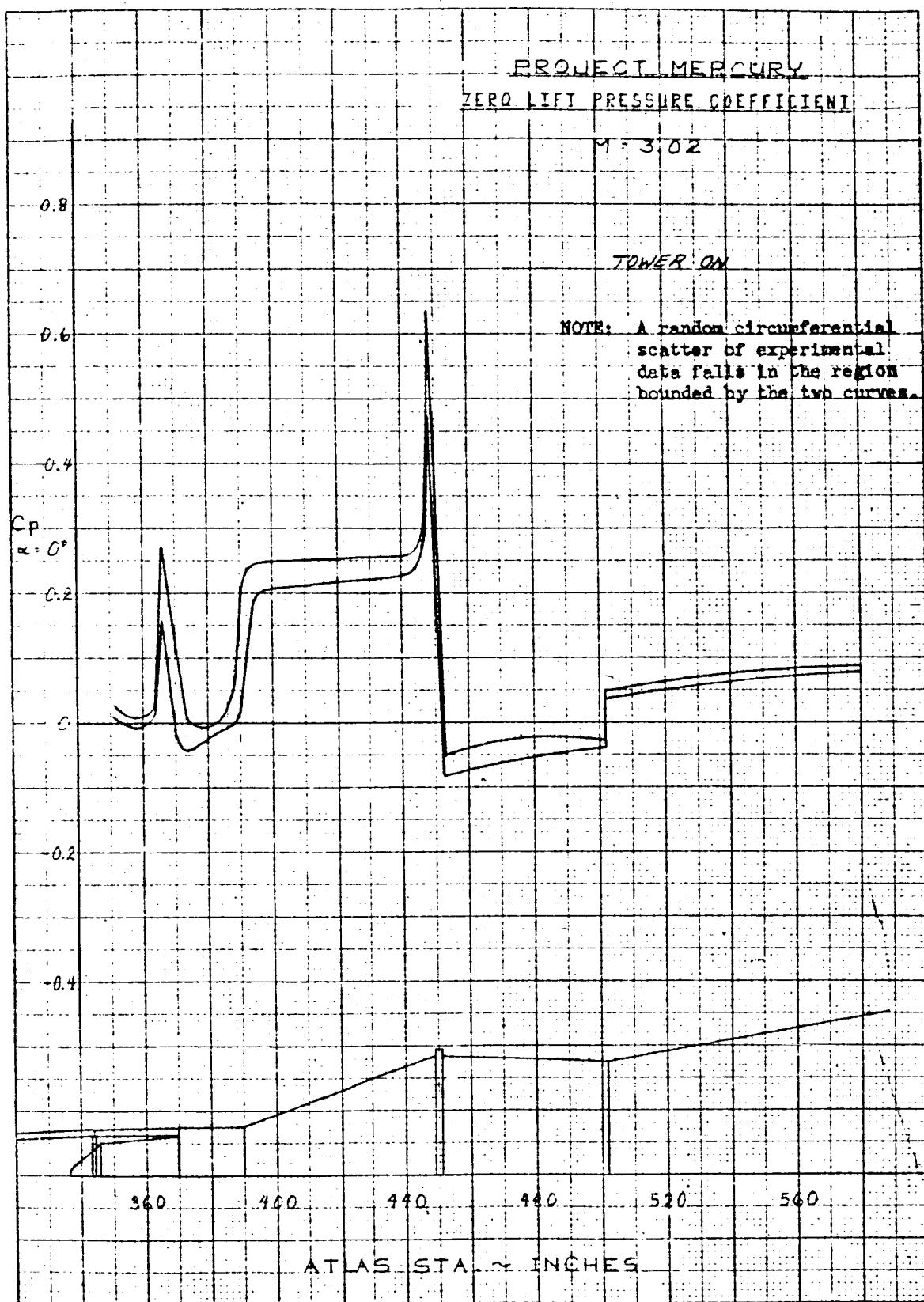


Figure 7

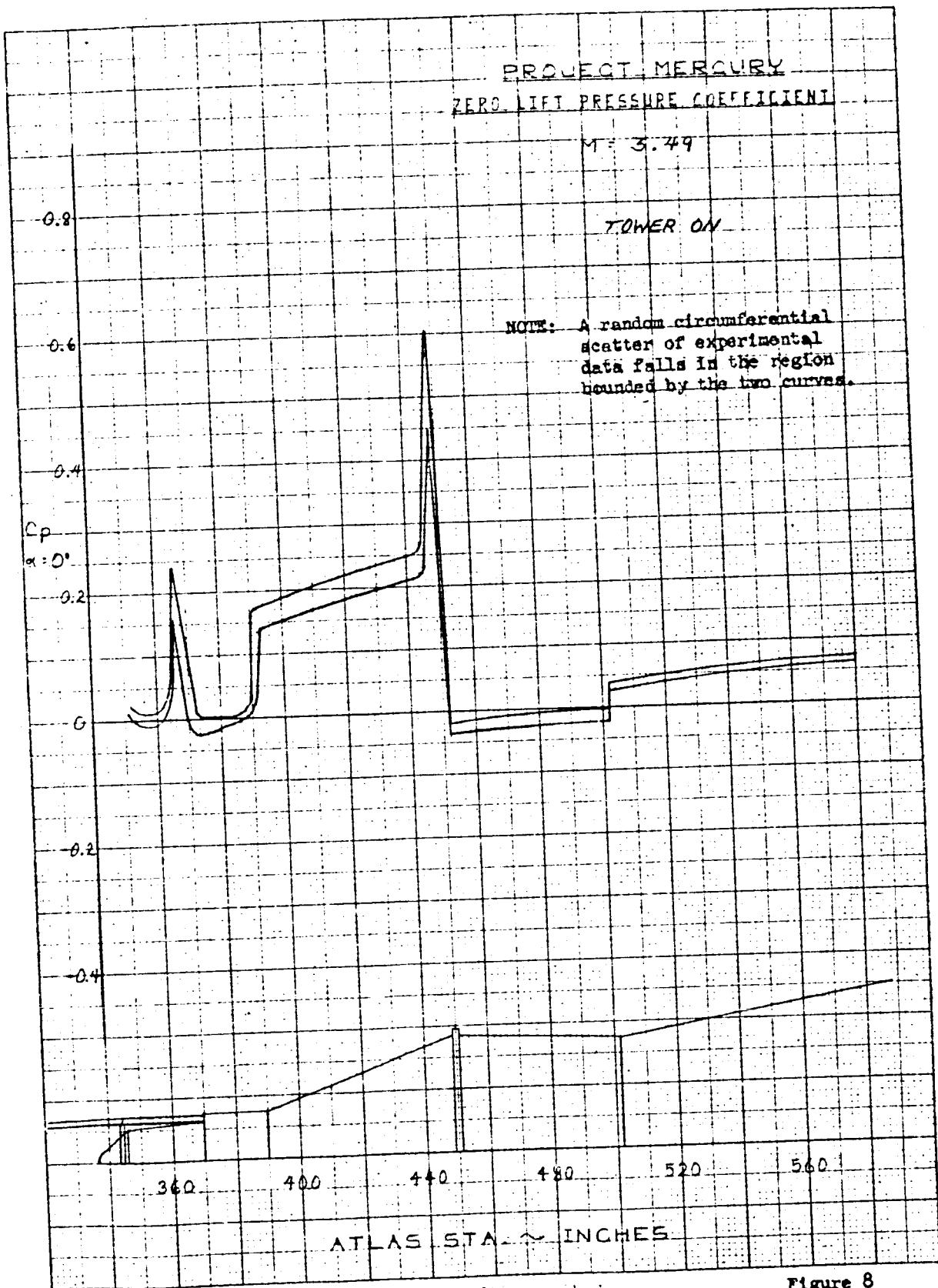


Figure 8

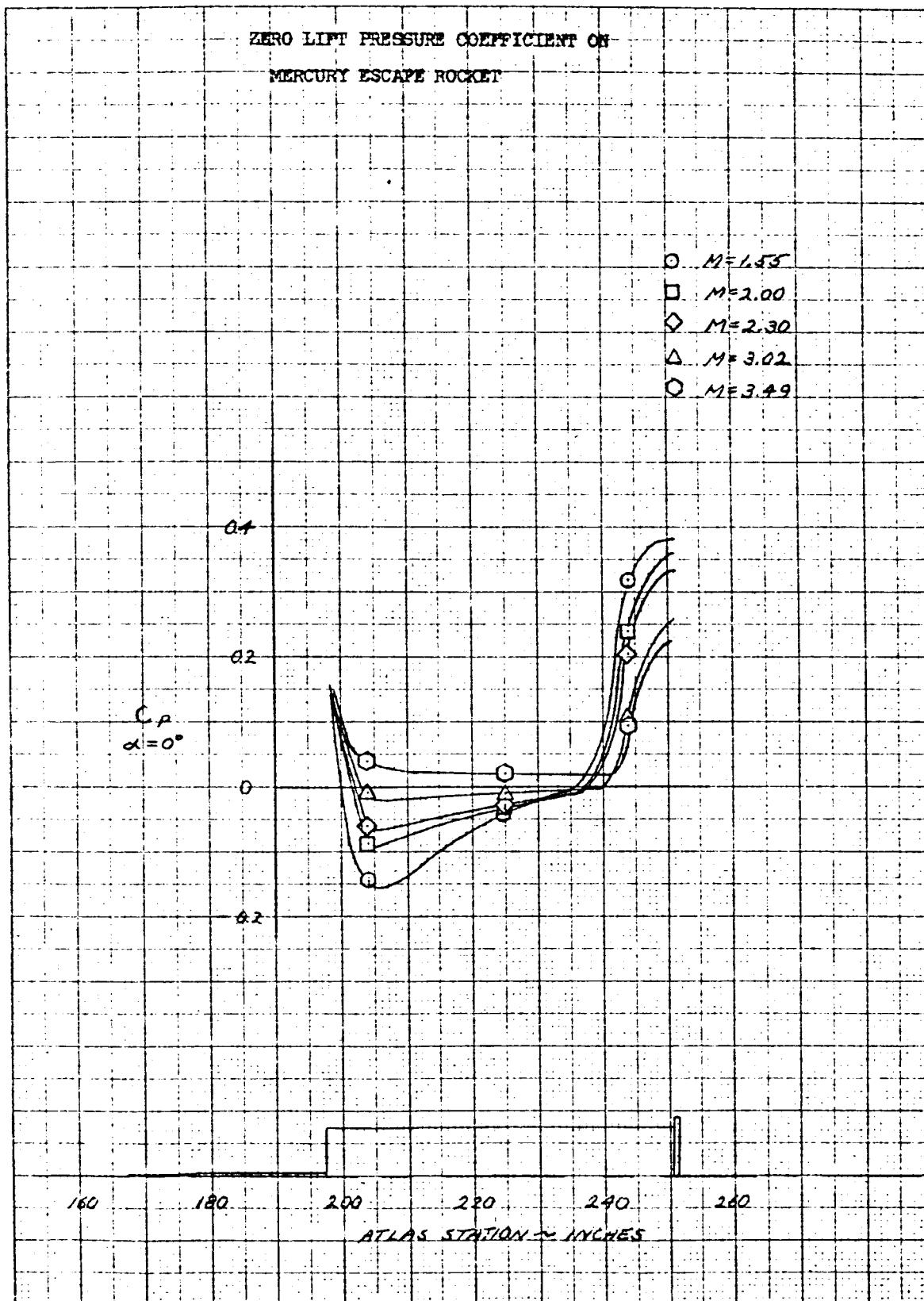


Figure 9

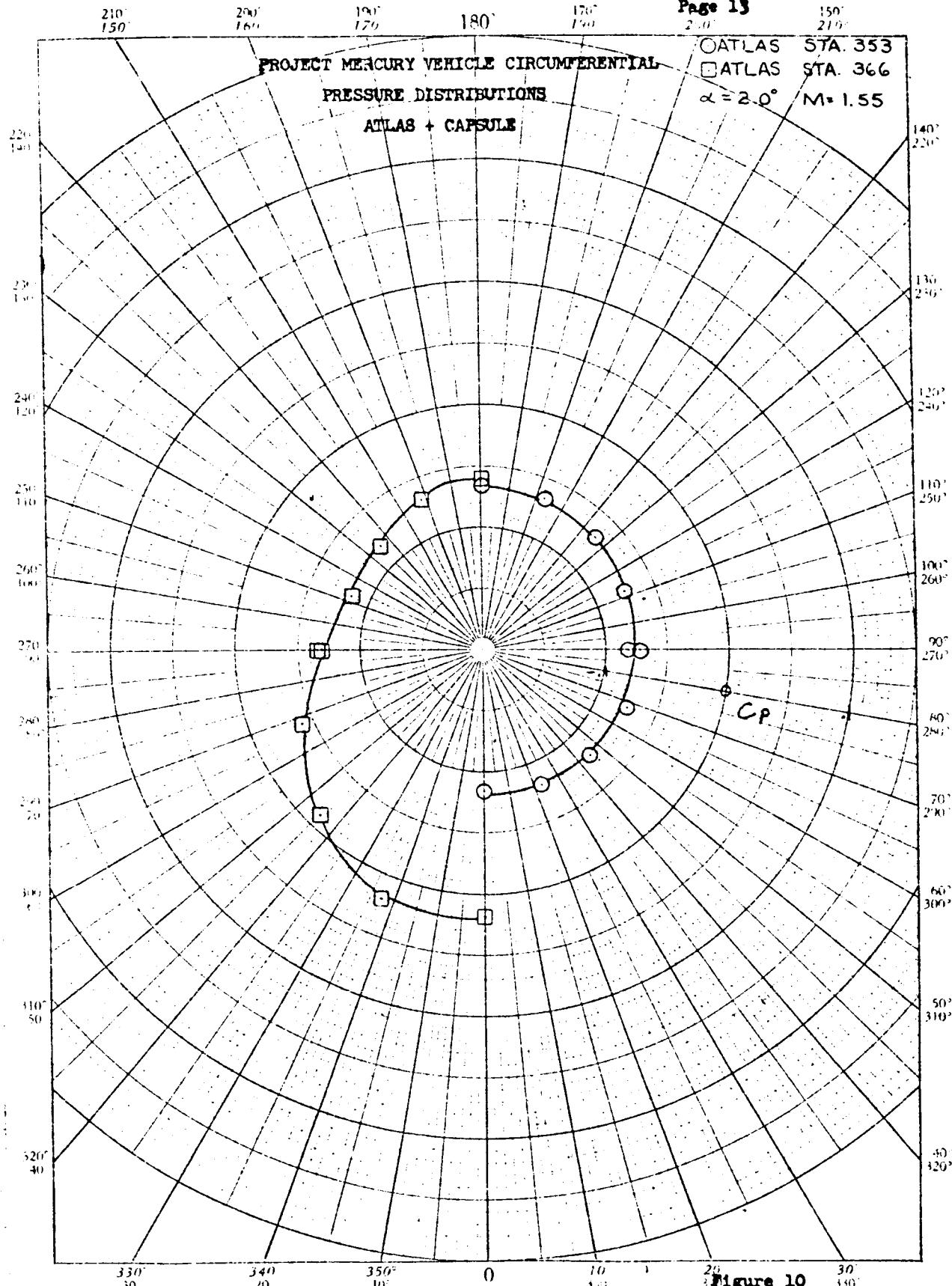


Figure 10

TN-59-0000-00304

Page 14

150°

210°

ATLAS STA. 353
ATLAS STA. 366
 $\alpha = 4.1^\circ$ $M=1.55$

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS

ATLAS + CAPSULE

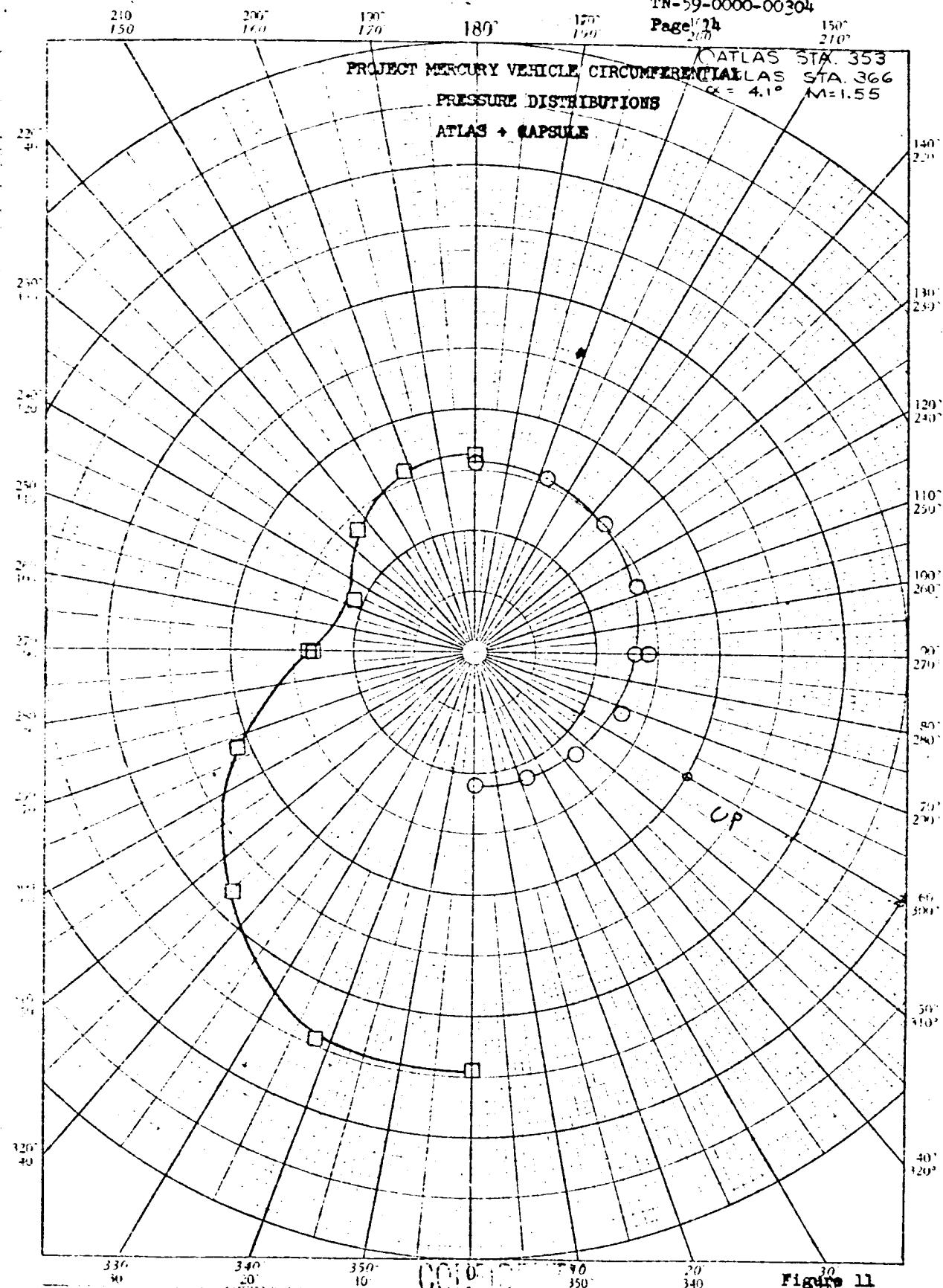


Figure 11

210°
150°200°
160°190°
170°180°
190°170°
200°PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS

ATLAS + CAPSULE

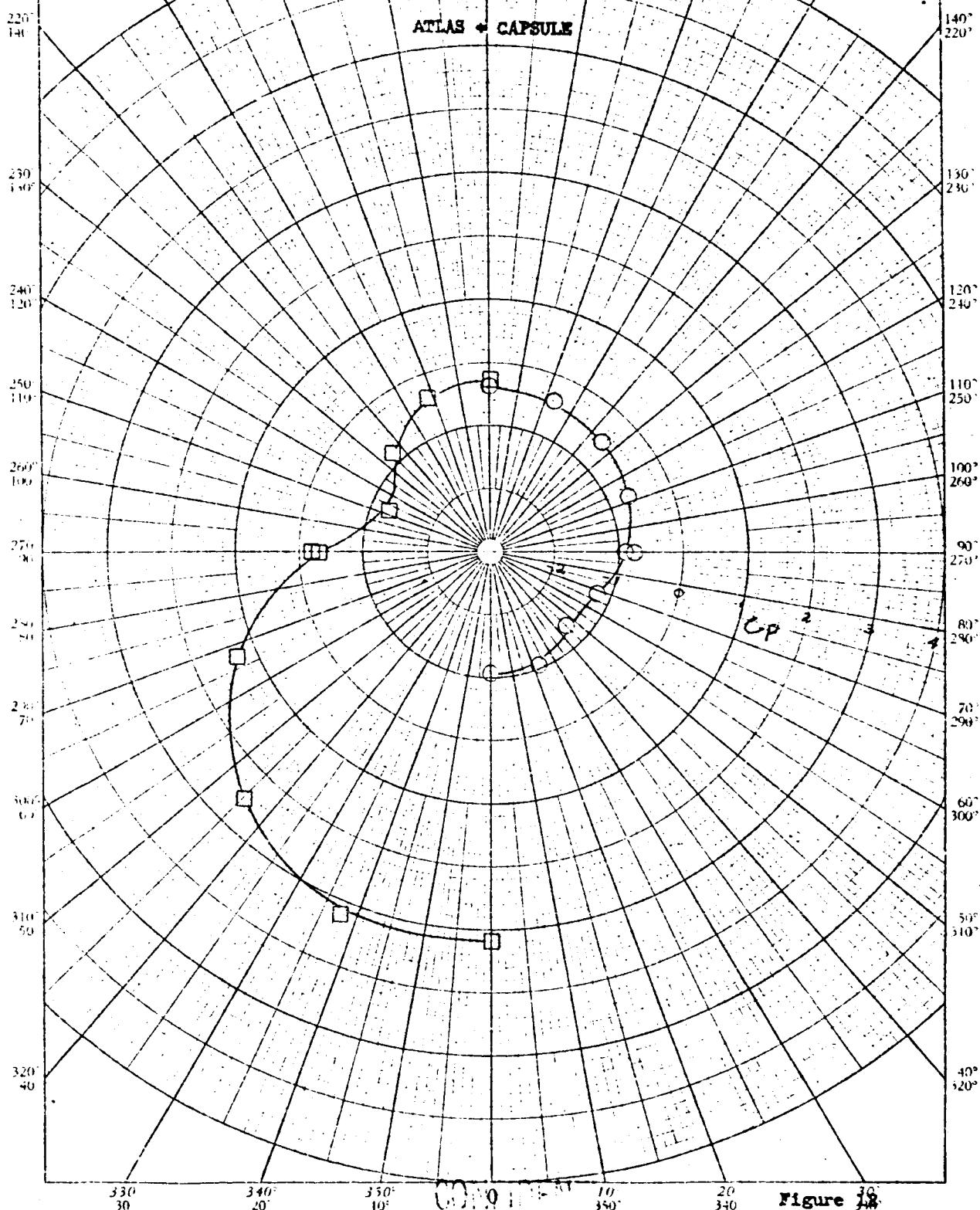
ATLAS STA. 353
ATLAS STA. 366
 $\alpha = 6.1^\circ$ $M = 1.55$ Figure 16
POLAR COORDINATE
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS

Figure 16

ATLAS STA. 373
ATLAS STA. 386
 $\alpha = 2.0^\circ$ $M = 1.55$

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE

POLAR COORDINATE 350-31
PROJECTION

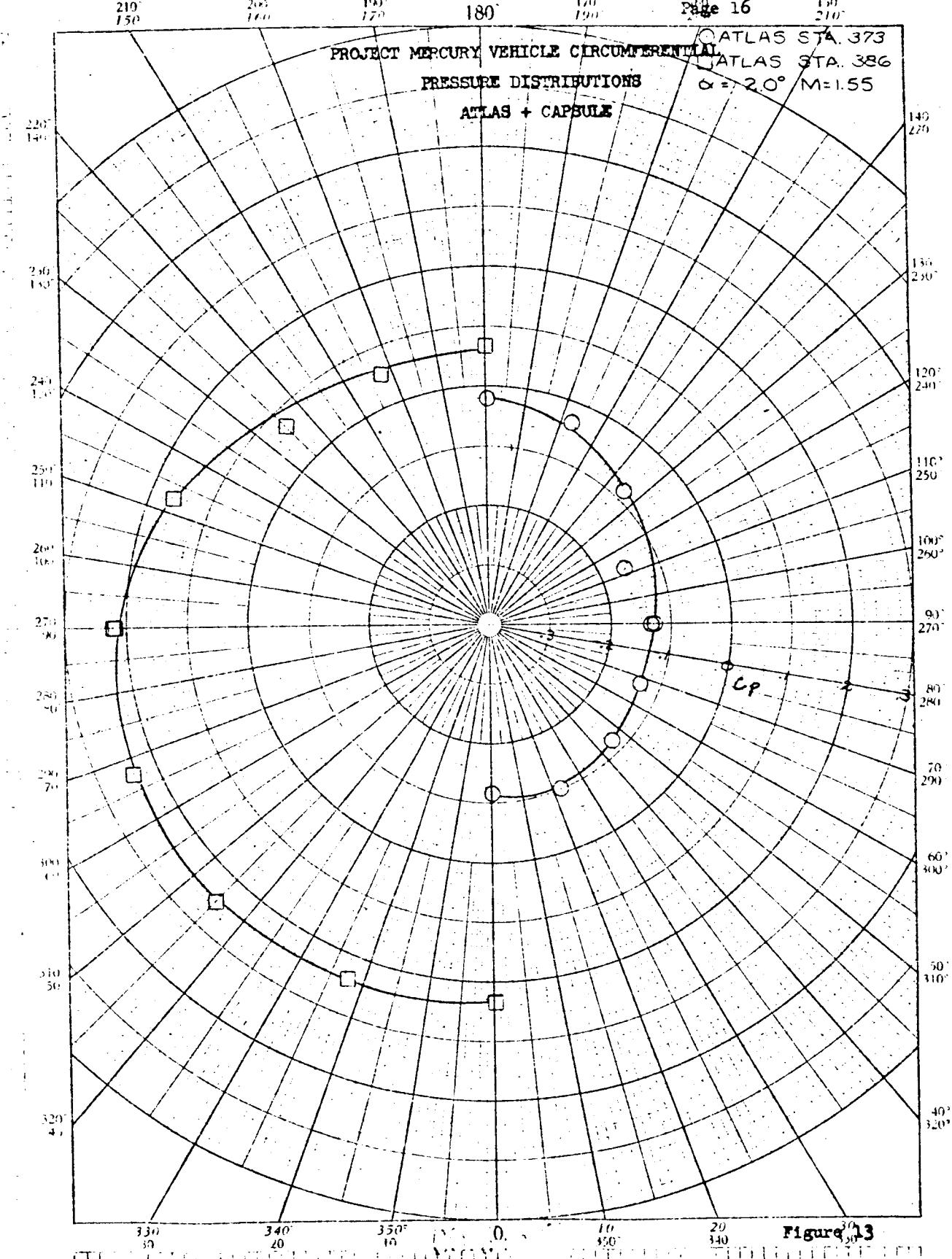
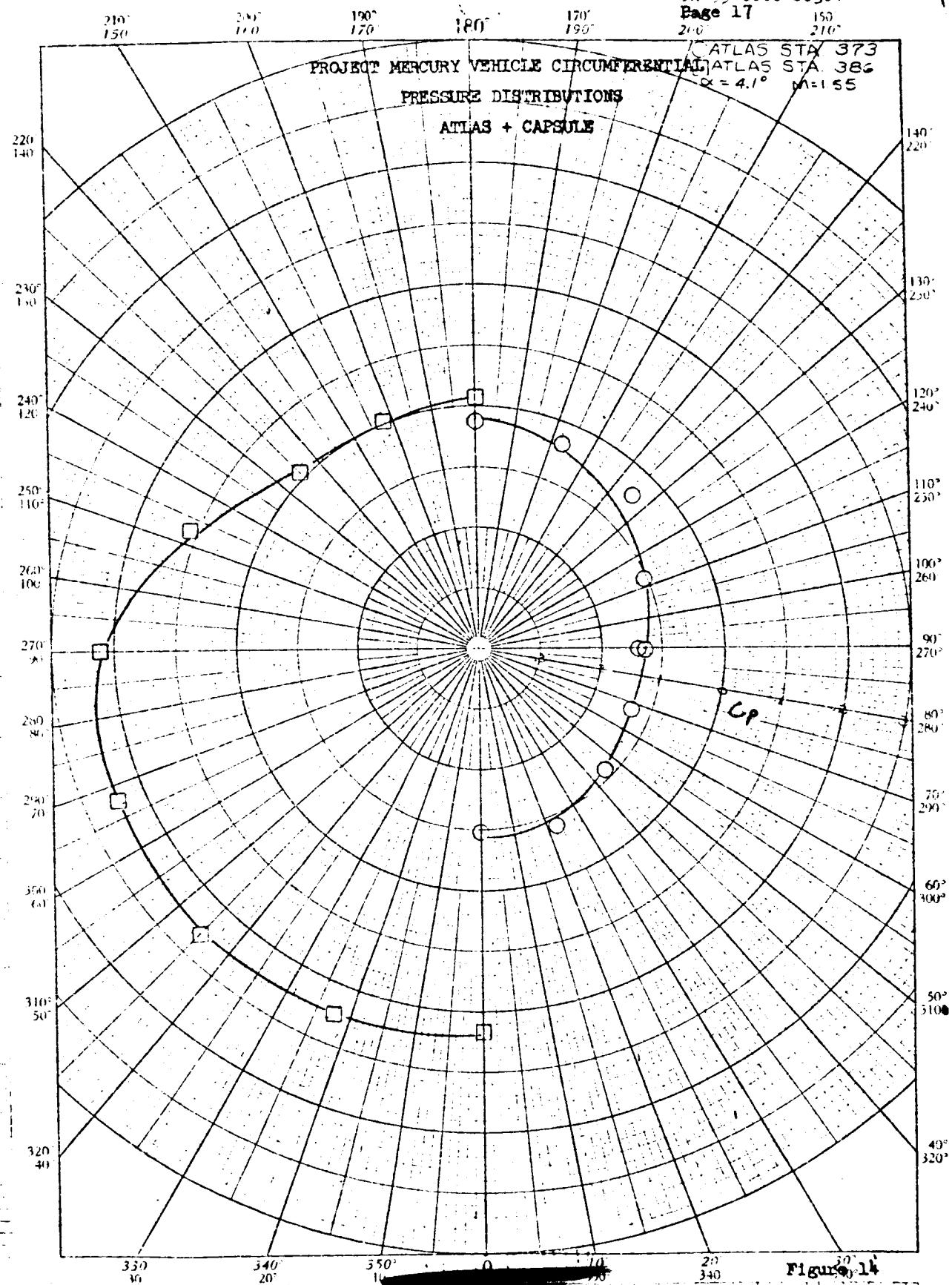


Figure 30-13



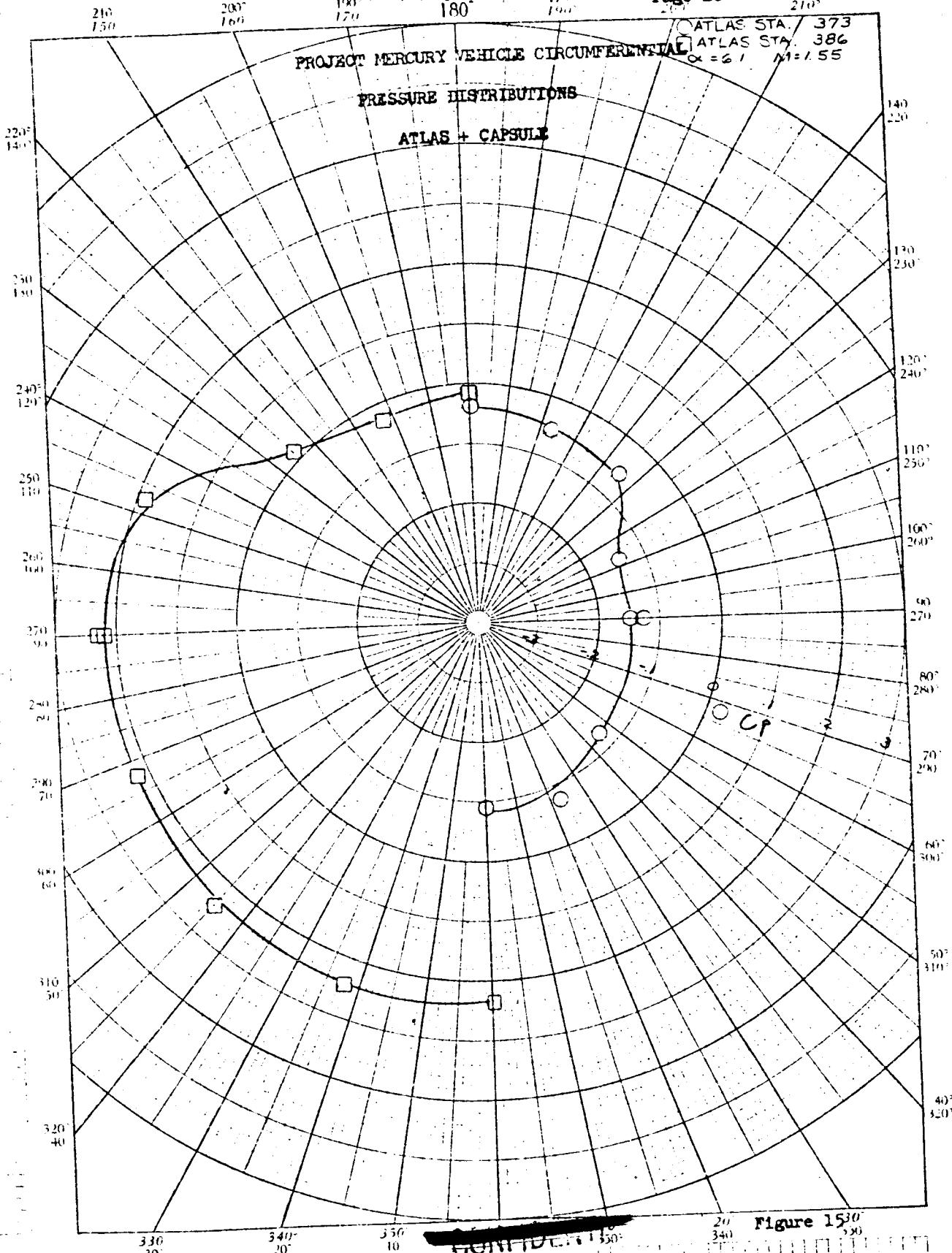
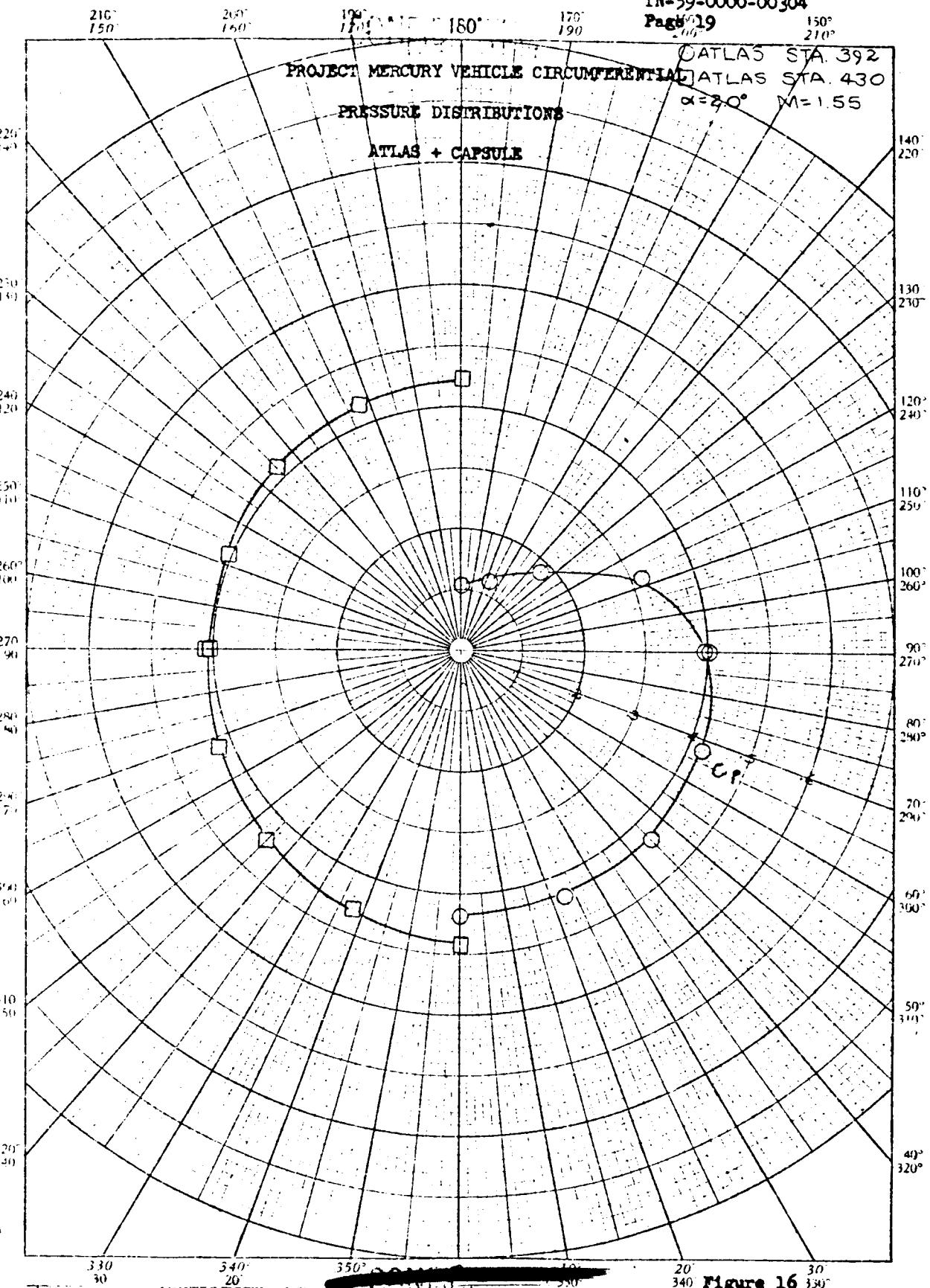


Figure 1530



TN-59-0000-00304

Page 21

140°

210°

ATLAS STA. 392
ATLAS STA. 430
 $\alpha = 6.1^\circ$ $M = 1.55$

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE

POLAR CO-ORDINATE SYSTEM

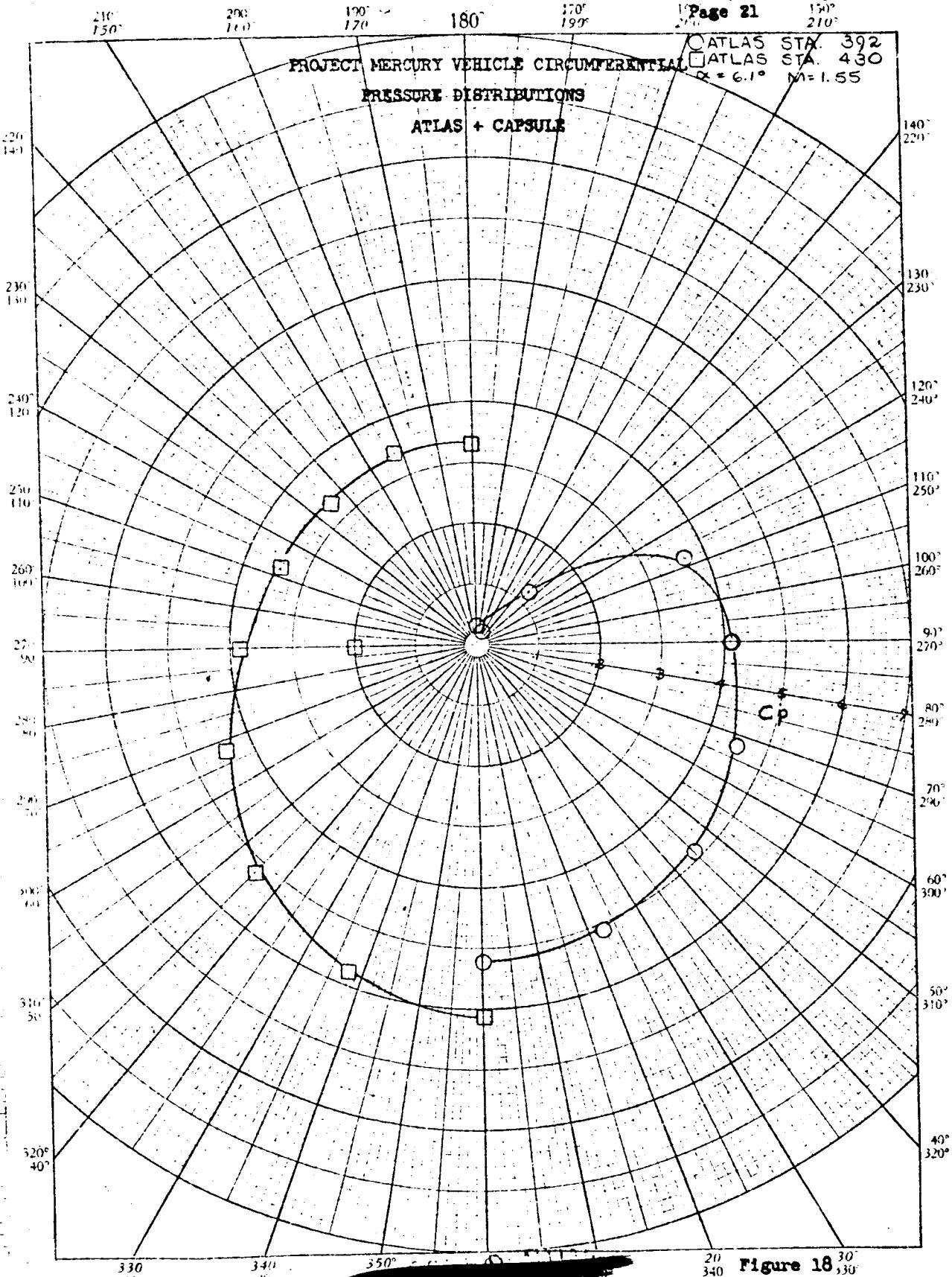


Figure 18

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Page 22

150°
150°
150°
150°

ATLAS STA. 448
ATLAS STA. 500
 $\alpha = 26^\circ$ M-1.55

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE

POLAR COORDINATE GRID
CIRCUMFERENTIAL PRESSURE DISTRIBUTION

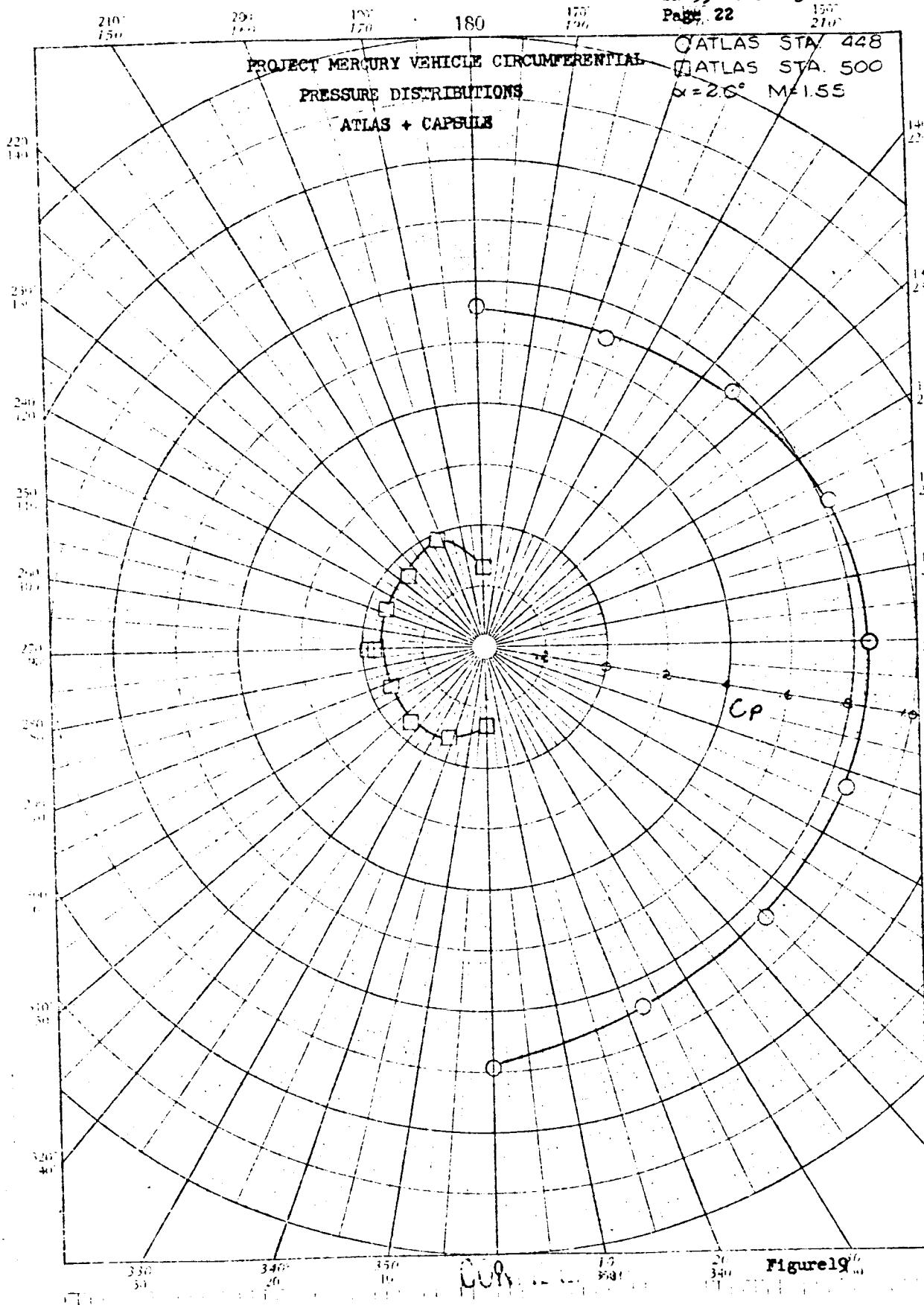


Figure 19

TN-59-0000-00304

Page 23

150°
210°

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE

ATLAS STA 448
ATLAS STA 500
 $\alpha = 4.1^\circ$ $M = 1.55$

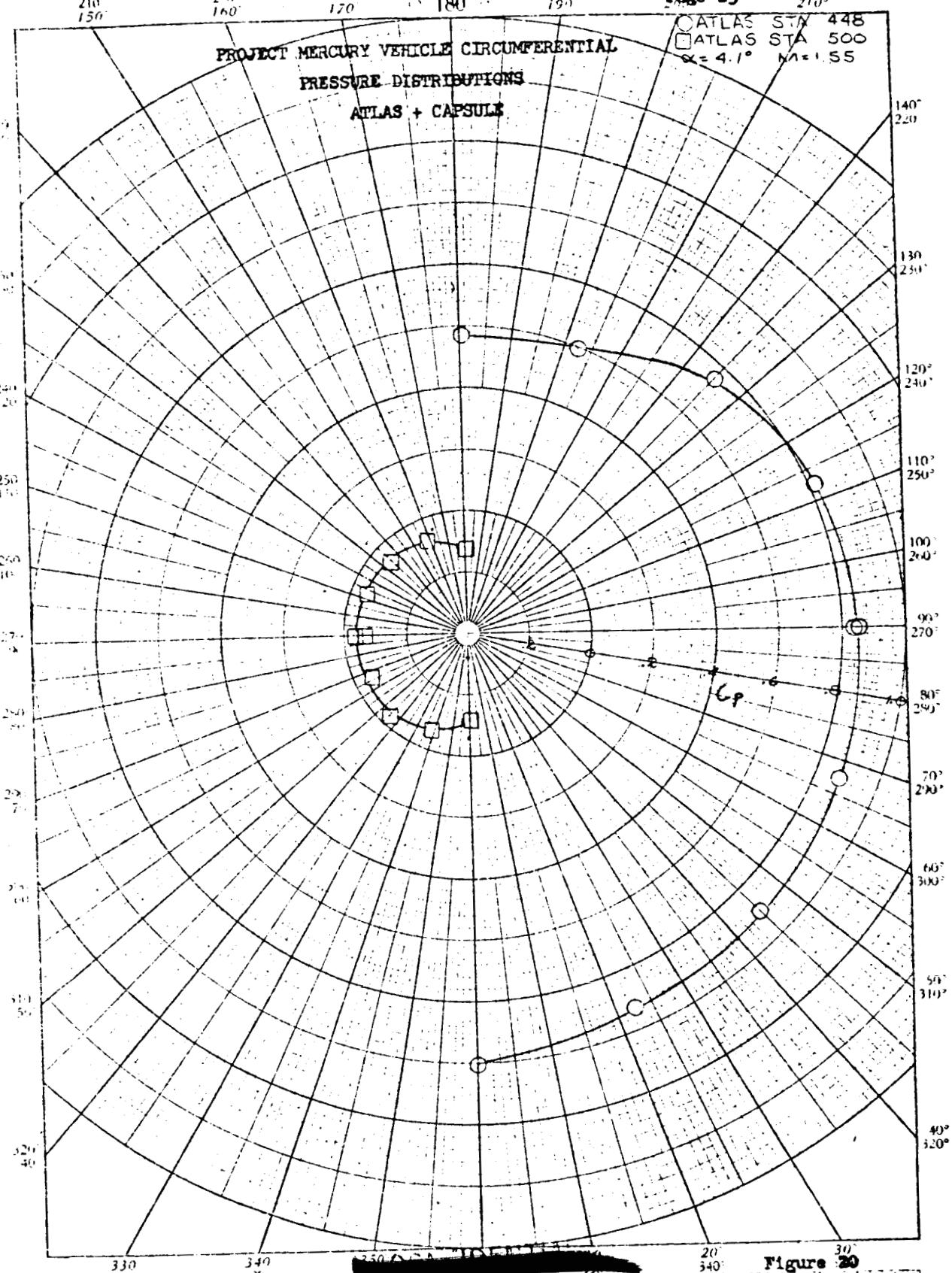


Figure 20

1307

2102

CATLAS STA 448
CATLAS STA 500
 $\alpha = 61^\circ$ $M = 1.55$

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
ATLAS + CAPSULE

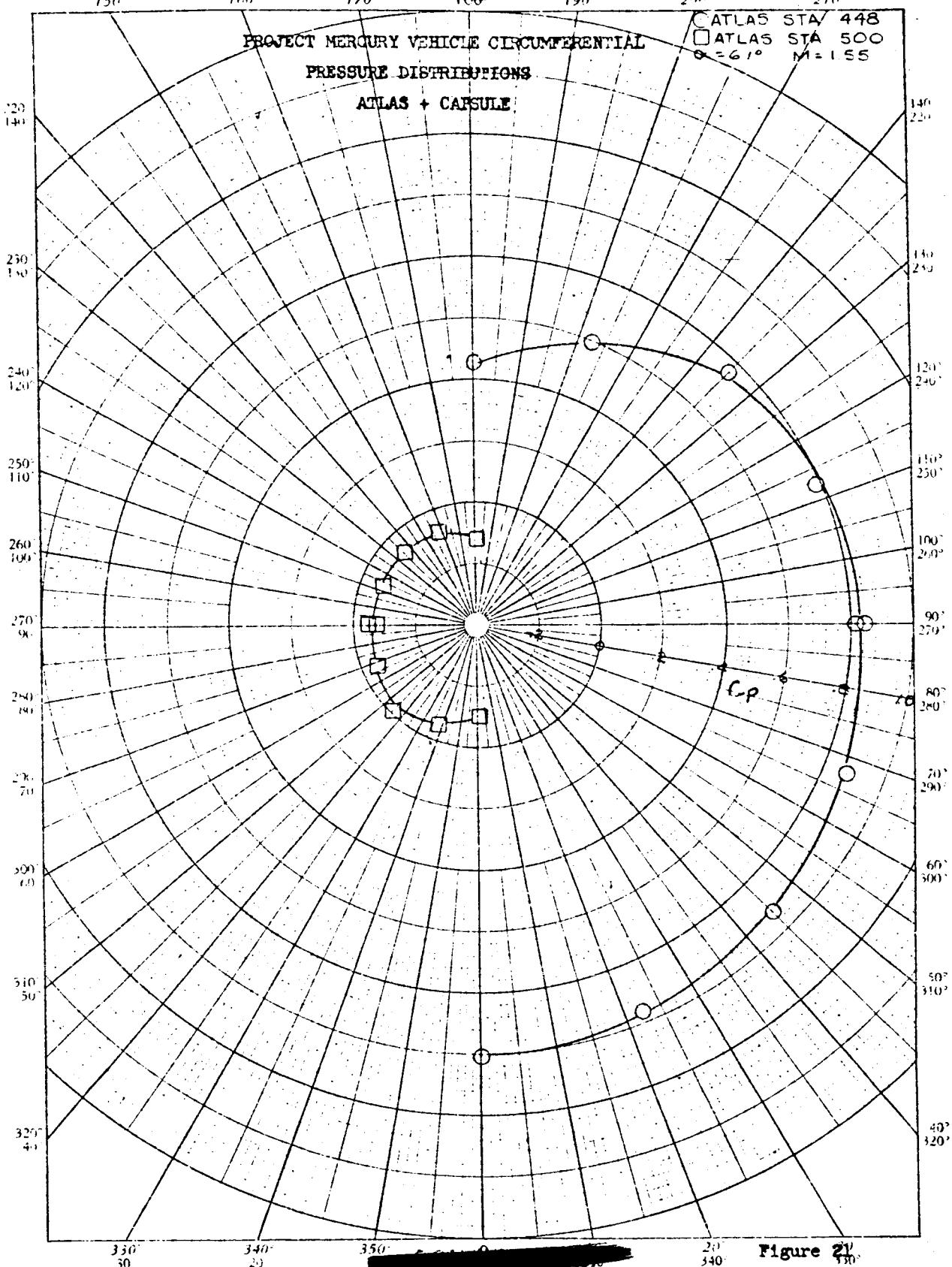
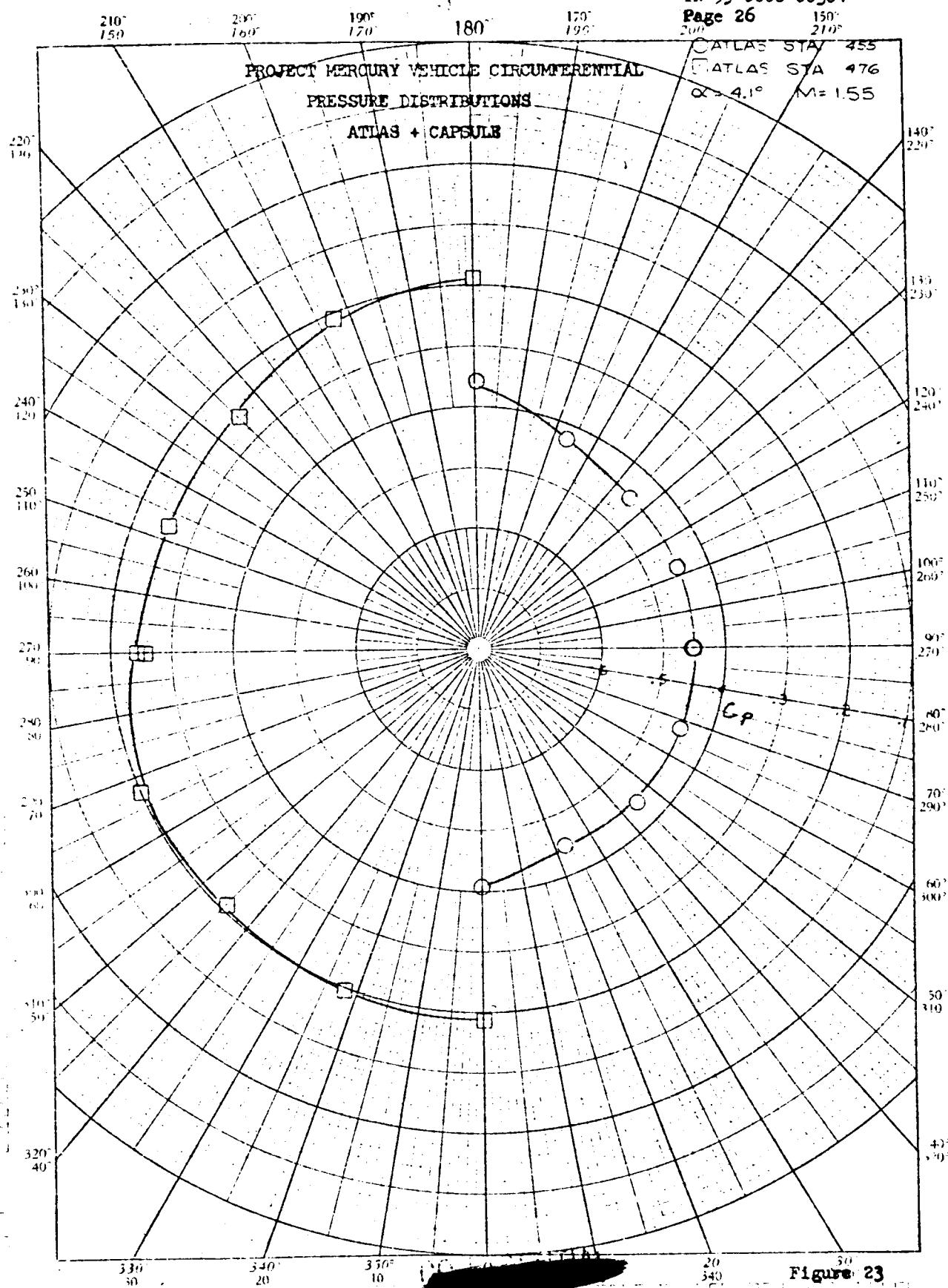


Figure 21.



210°
150°200°
160°190°
170°180°
190°170°
160°

150°

210°

ATLAS STA. 455
ATLAS STA. 476
 $\alpha = 6.1^\circ$ $M = 1.55$ PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS

ATLAS + CAPSULE

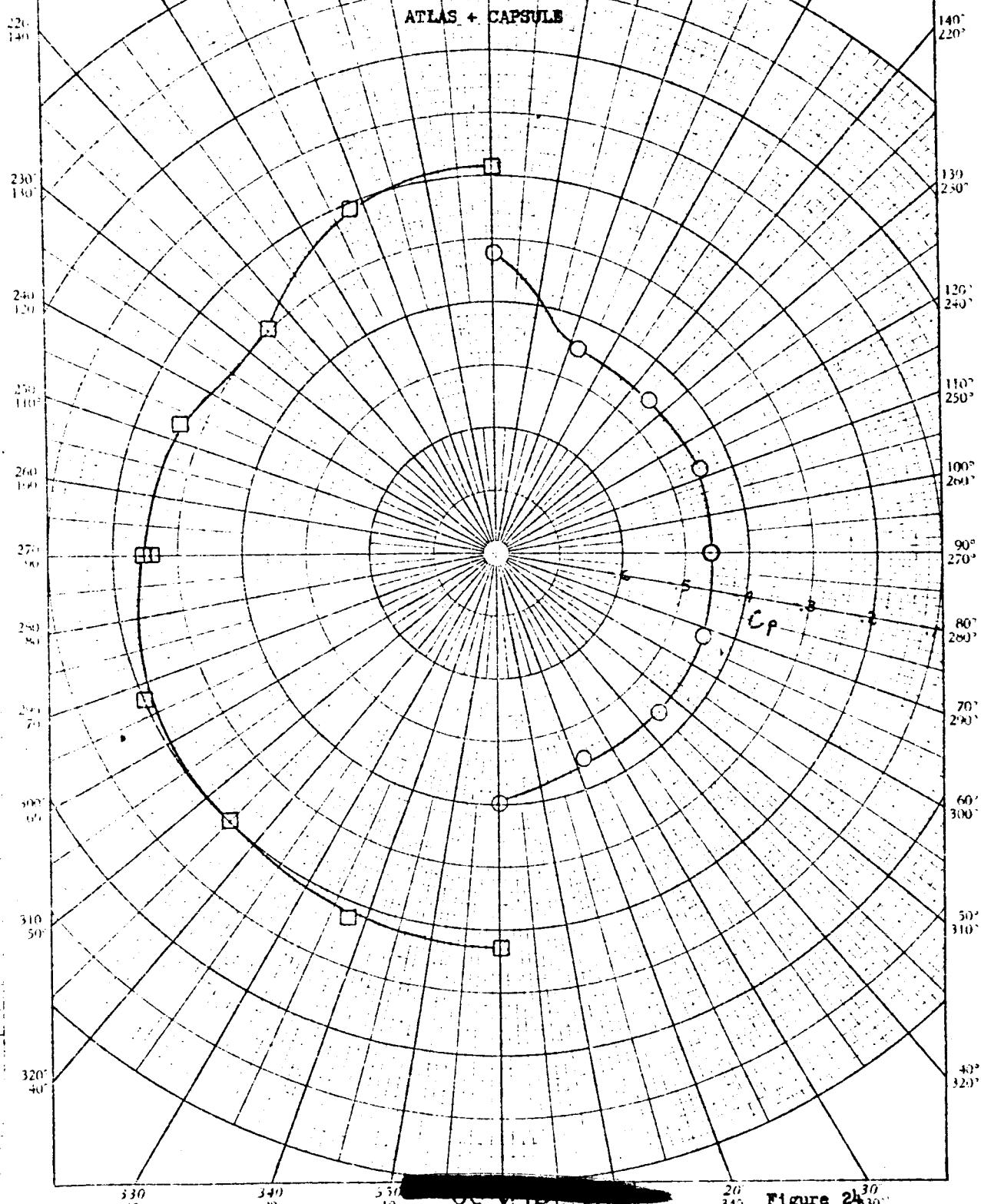
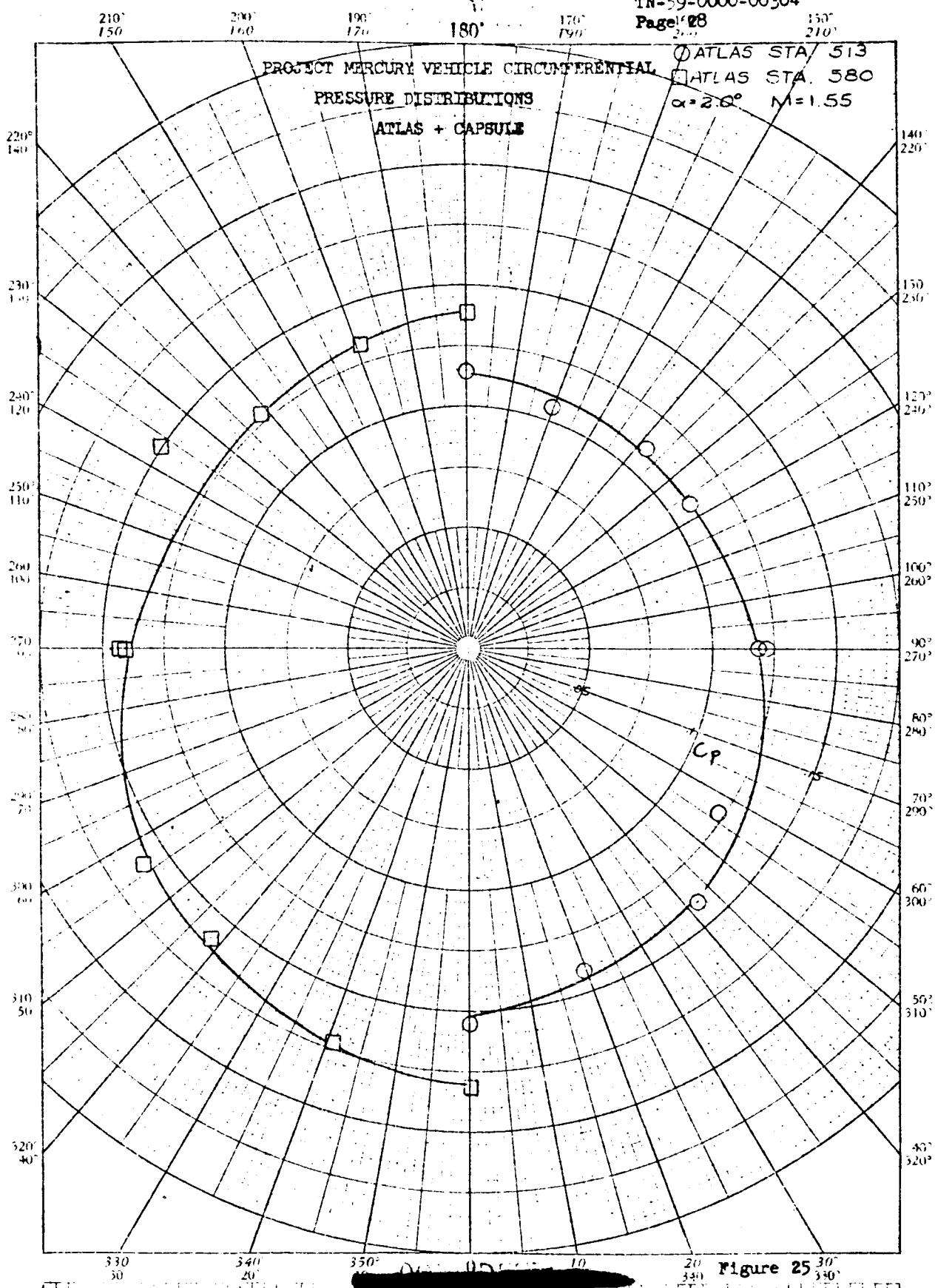
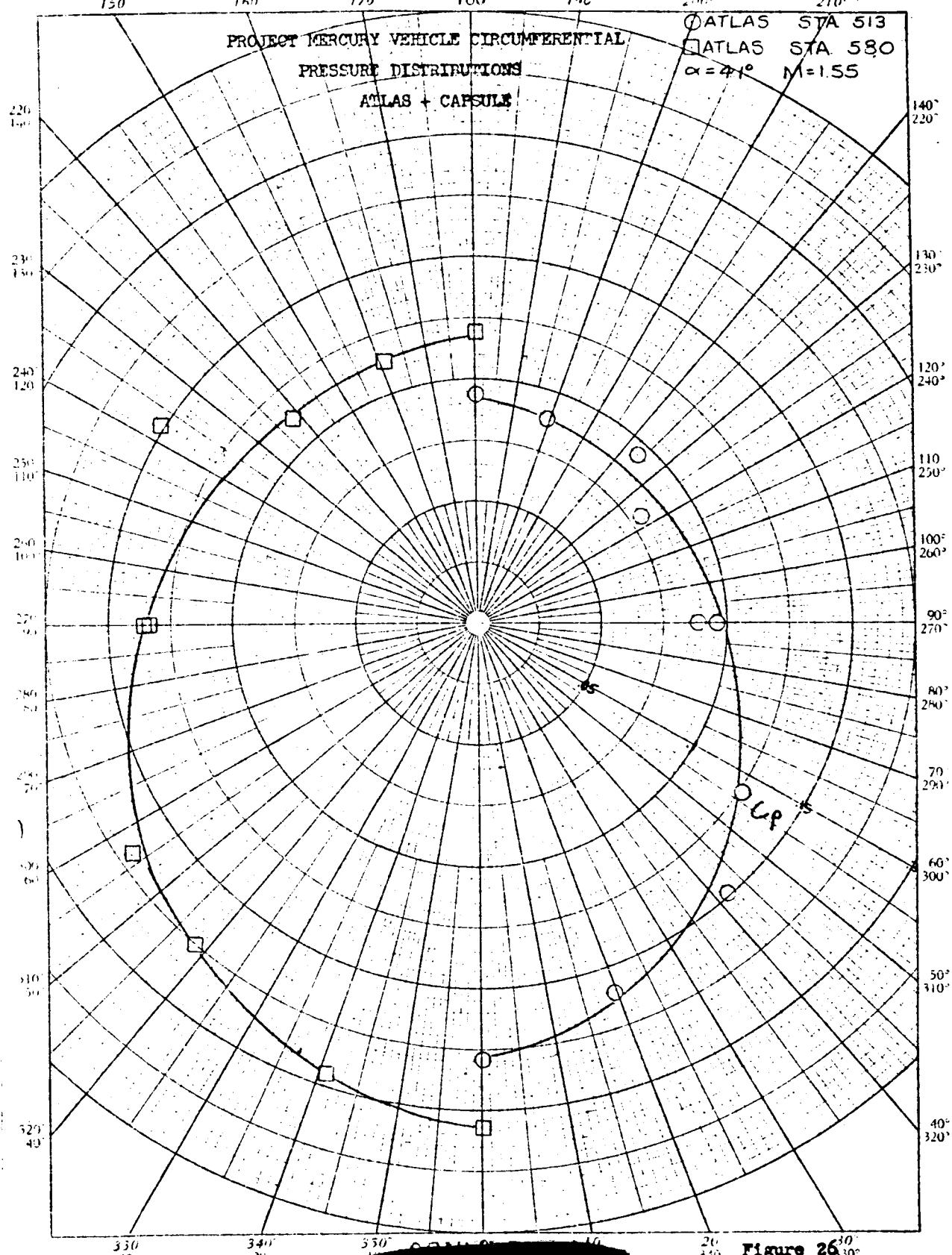


Figure 24

30°





ATLAS STA 513
ATLAS STA 580
 $\alpha = 6.1^\circ$ $M = 1.55$ PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS

ATLAS + CAPSULE

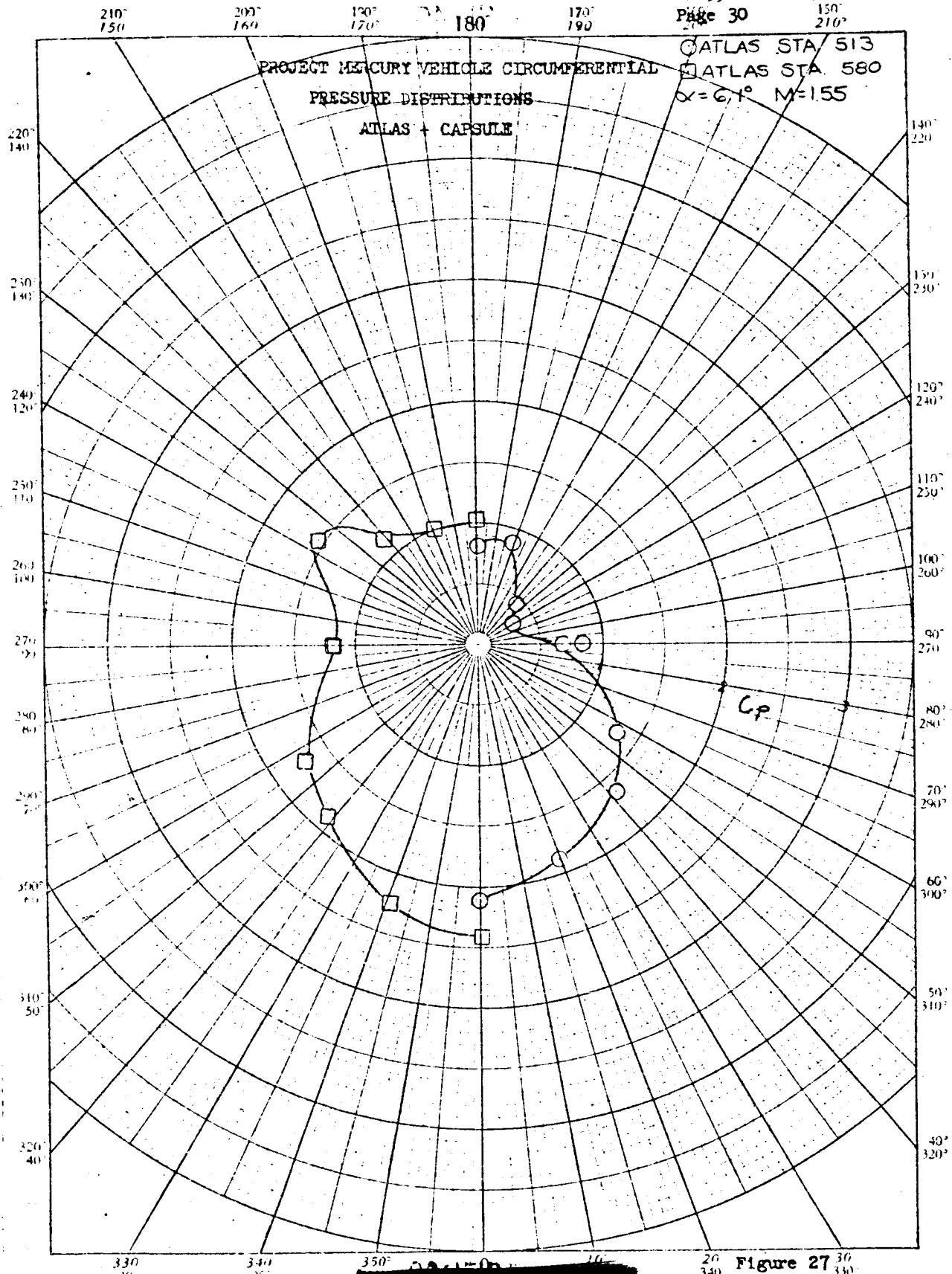
POLAR COORDINATE 350-31
REFLECTED

Figure 27 36

○ ATLAS STA 204
 □ ATLAS STA 225
 $\alpha = 20^\circ$ $M = 1.55$

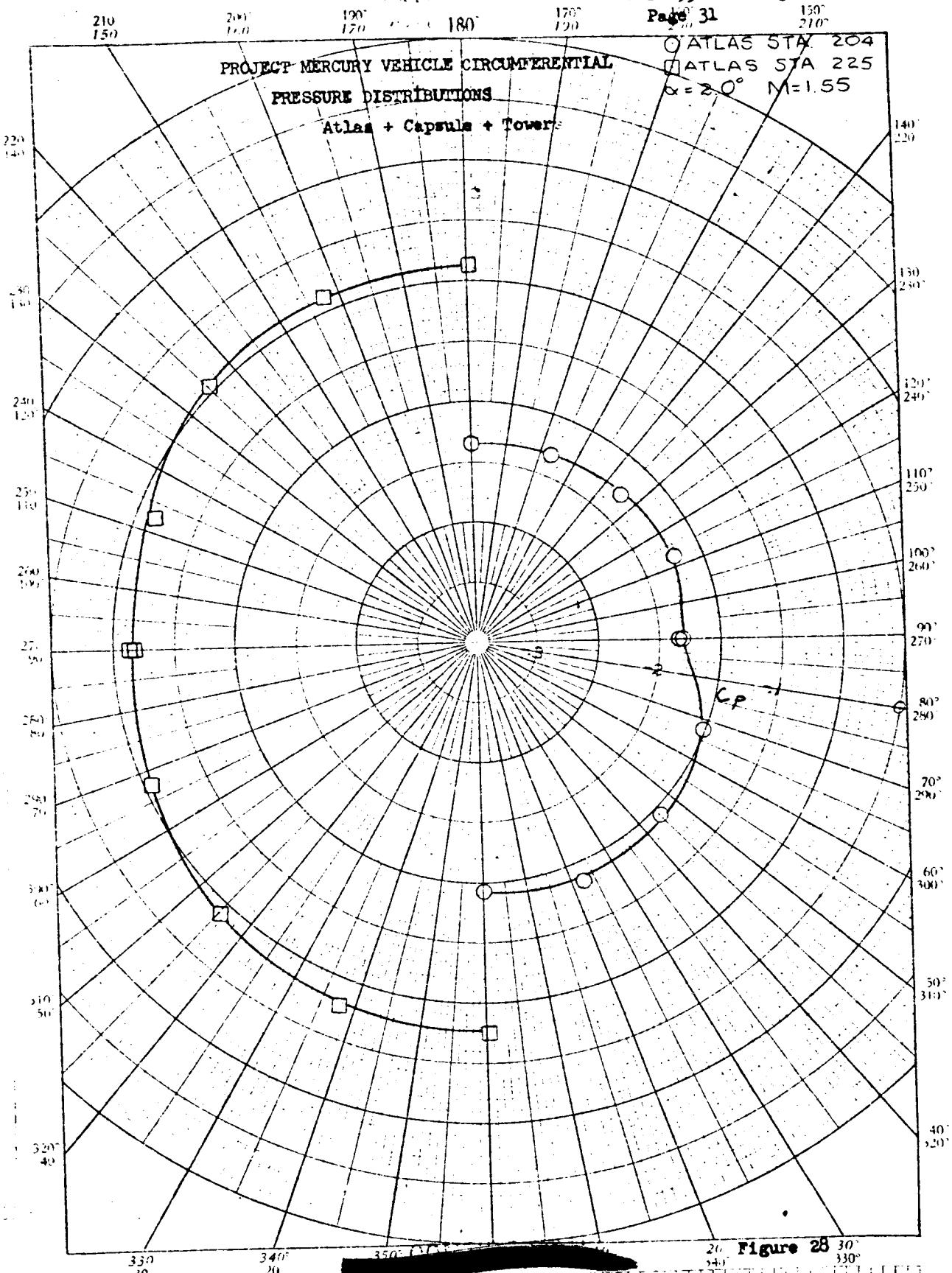


Figure 28 30° 330°

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Page 32

150°

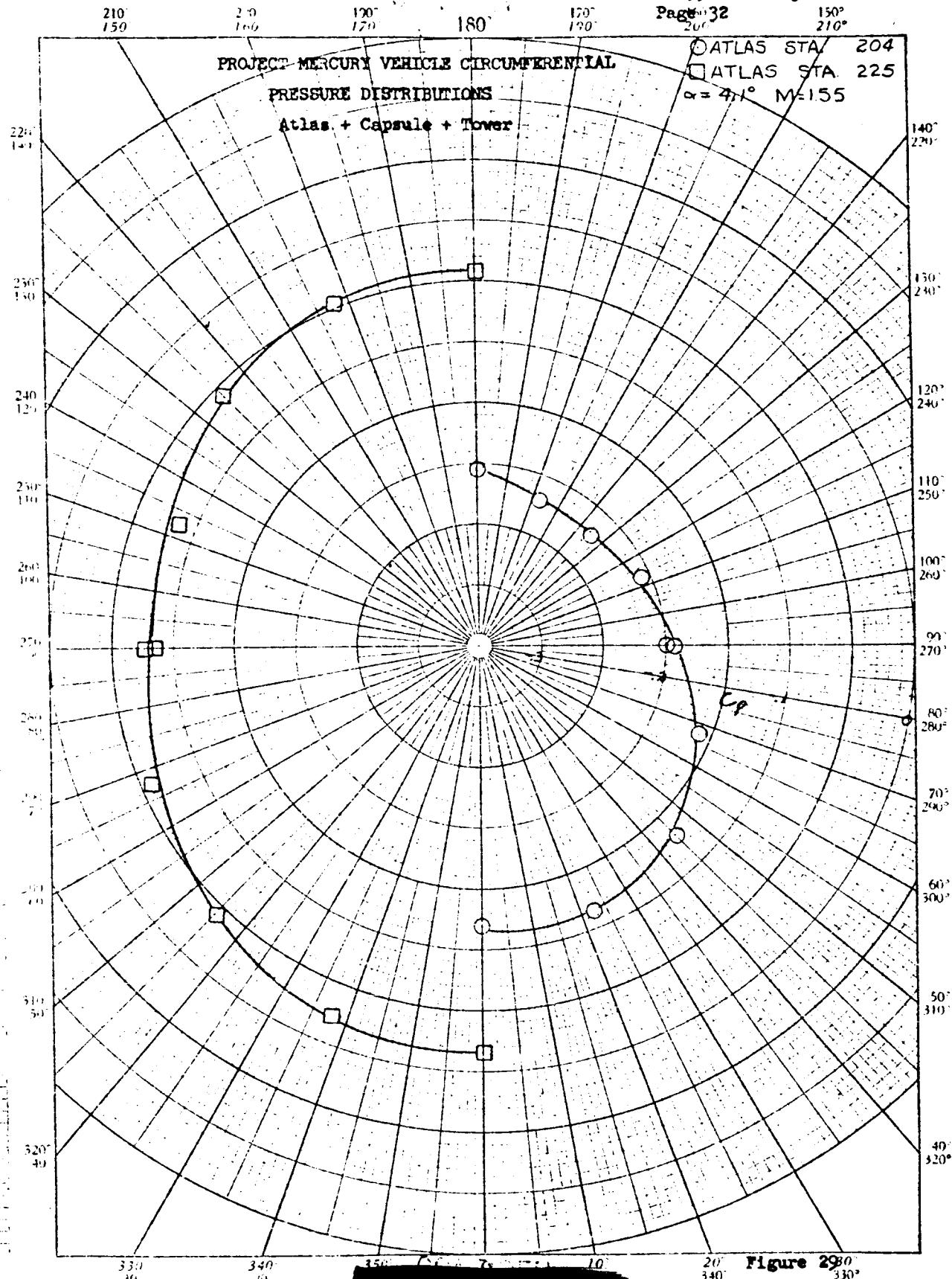
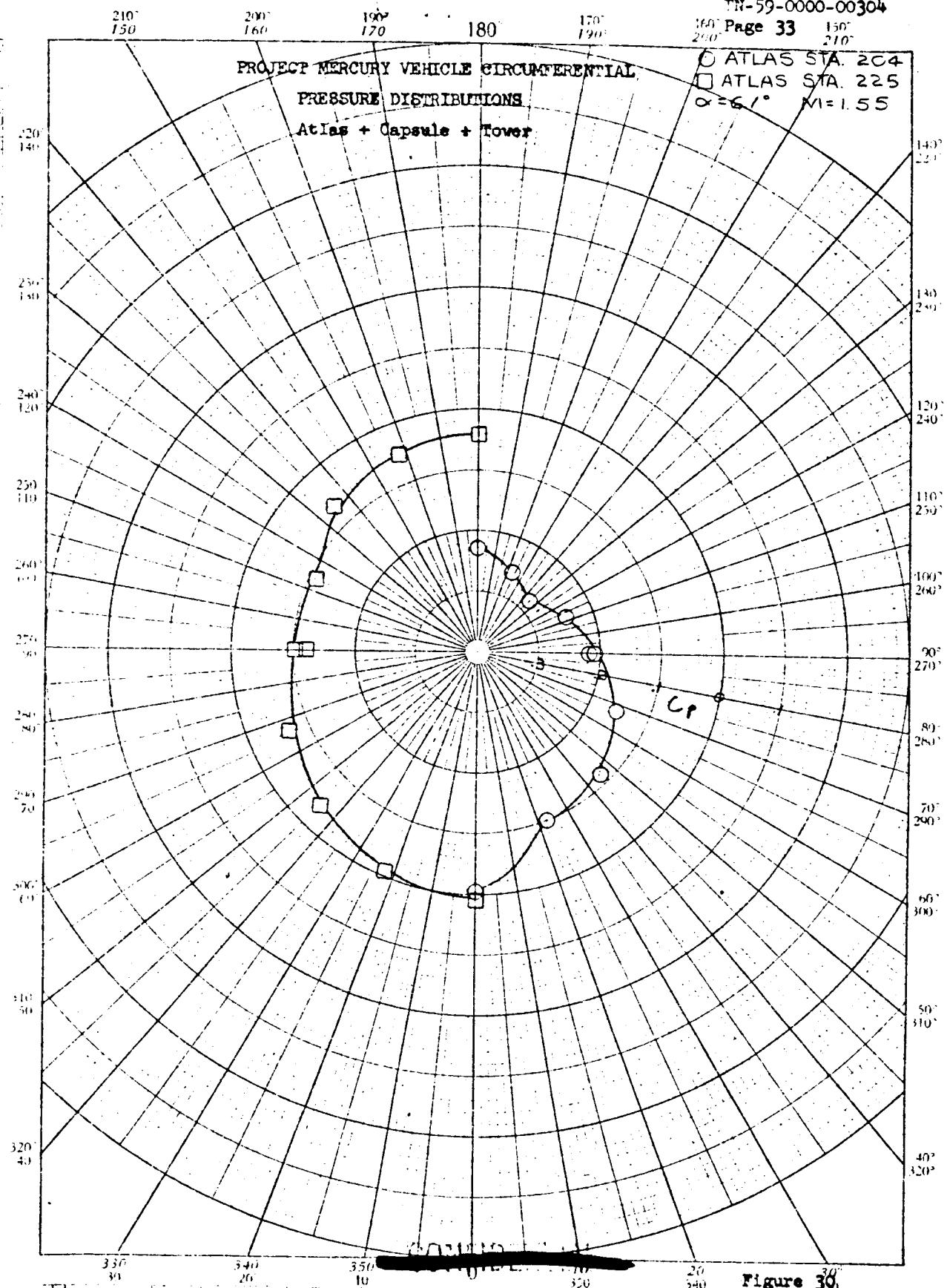


Figure 2930



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Page 35

150° 210°

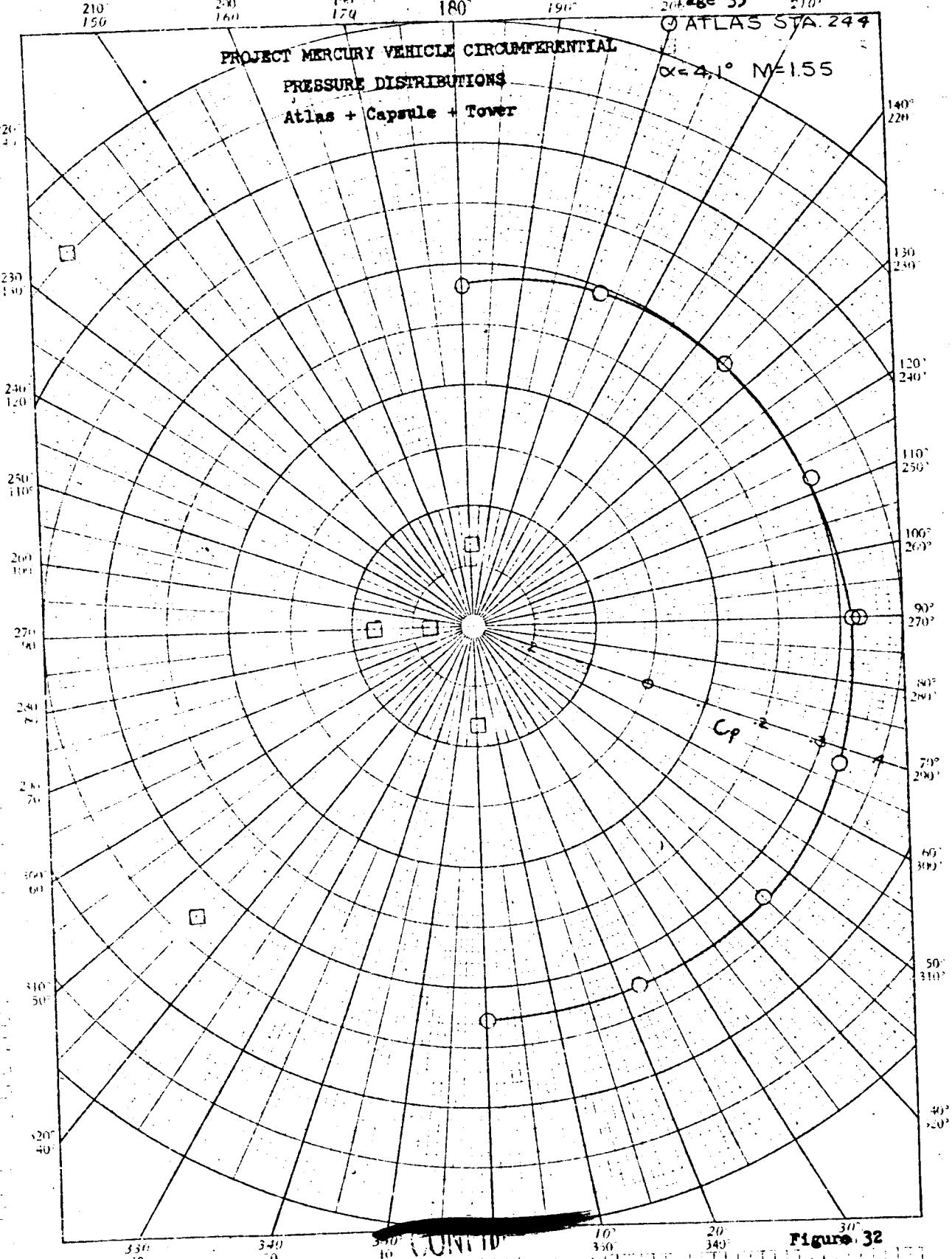
ATLAS STA. 244

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL

PRESSURE DISTRIBUTIONS

Atlas + Capsule + Tower

$\alpha = 41.1^\circ$ $M = 1.55$



REF ID: A359-31
POLAR CO-ORDINATE PRESSURE DISTRIBUTION

Figure 32

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Page 36

150°
210°

ATLAS STA 244

$\alpha = 6.1^\circ$ M = 1.55

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL

PRESSURE DISTRIBUTIONS

Atlas + Capsule + Tower

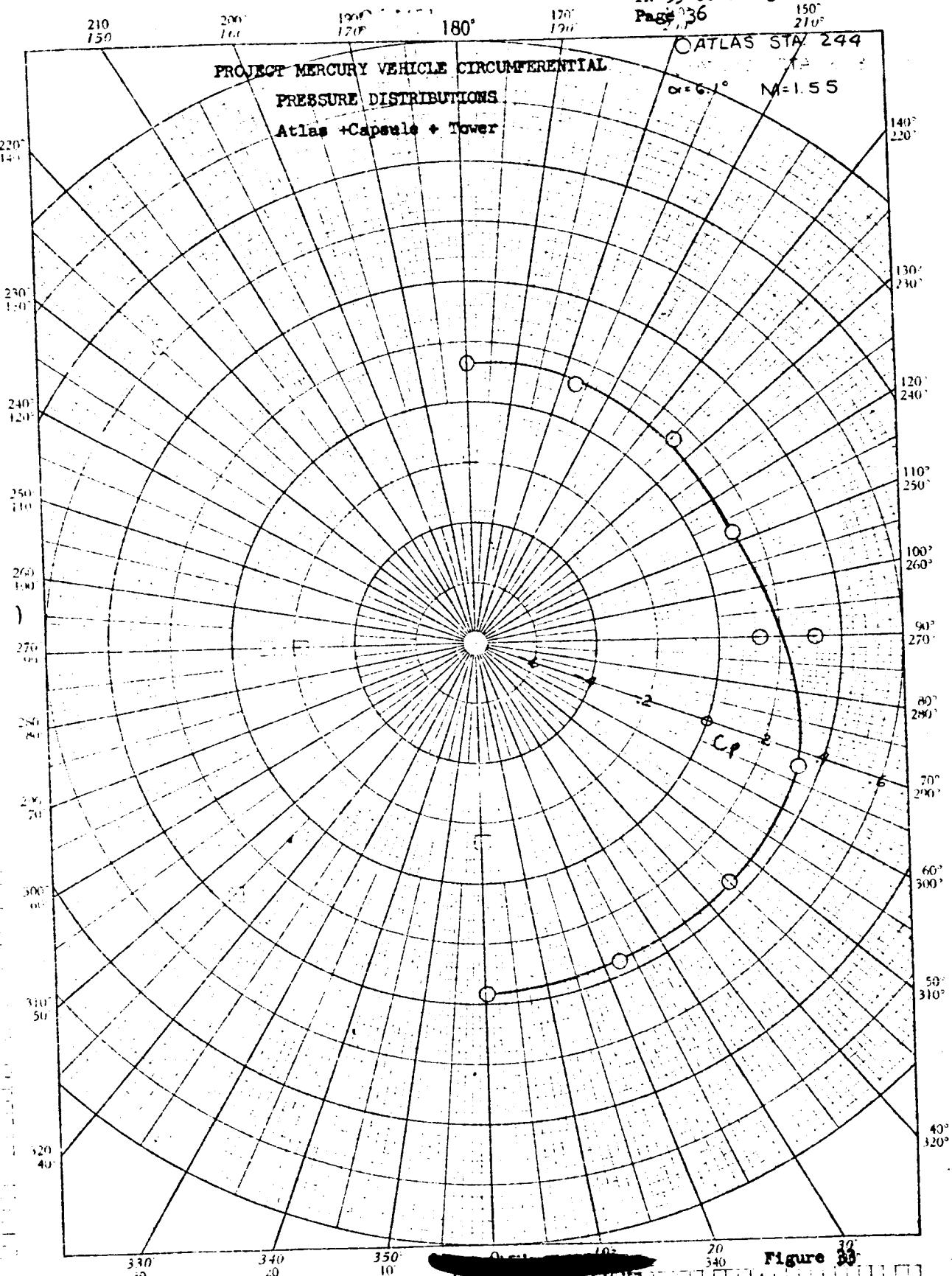
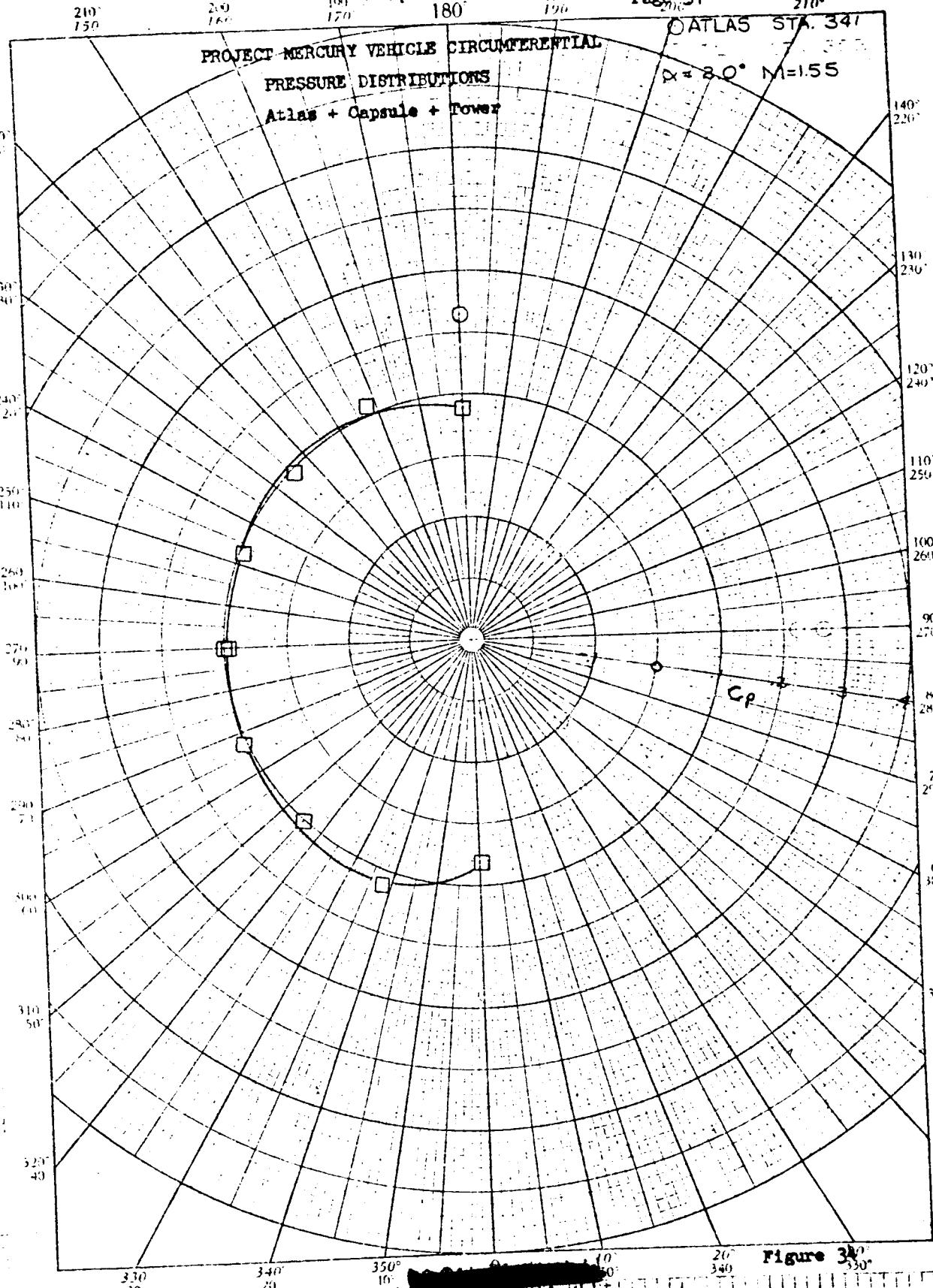


Figure 36



ATLAS STA. 341

 $\alpha = 41^\circ$ $M_1 = 1.55$

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL

PRESSURE DISTRIBUTIONS

Atlas + Capsule + Tower

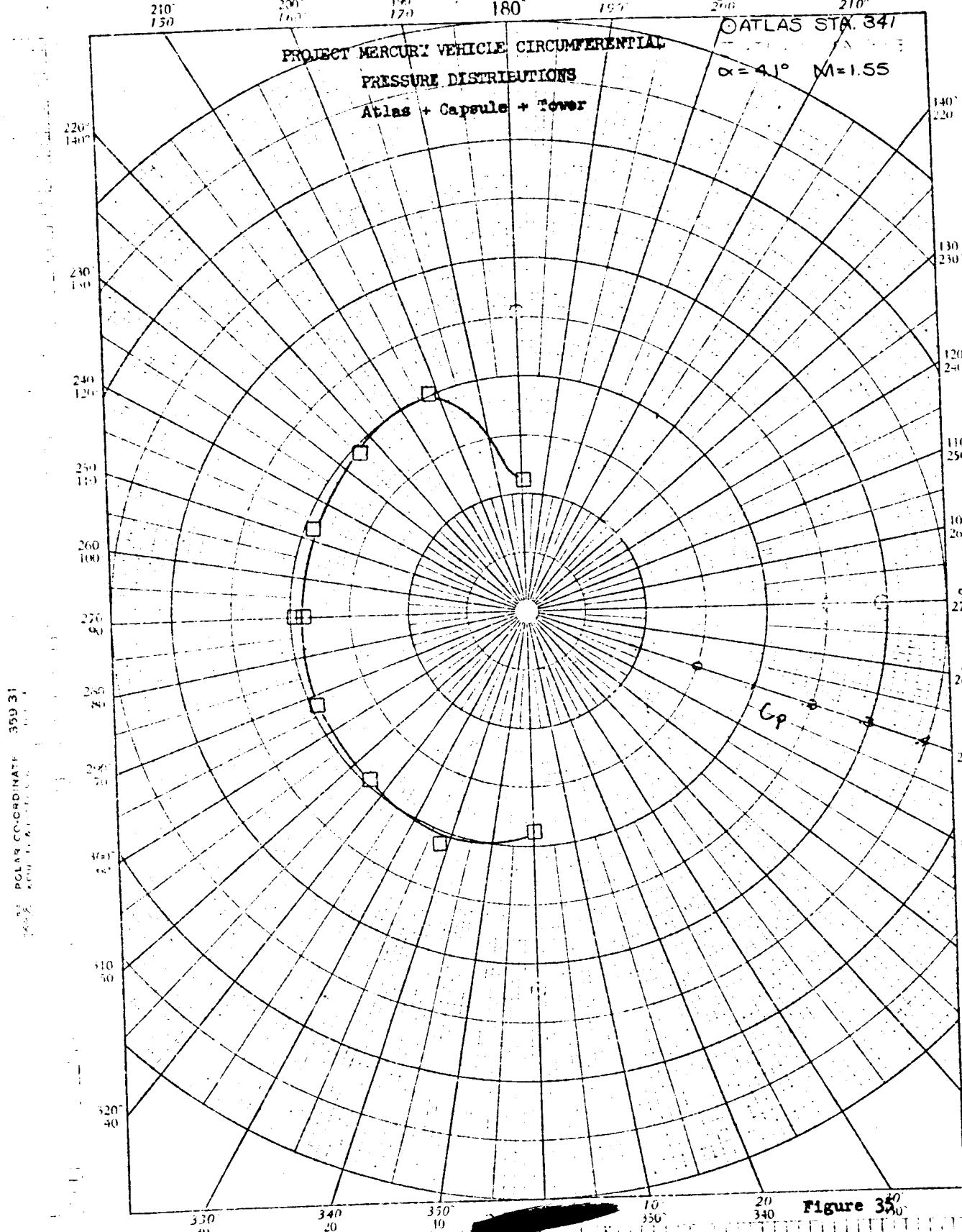


Figure 340

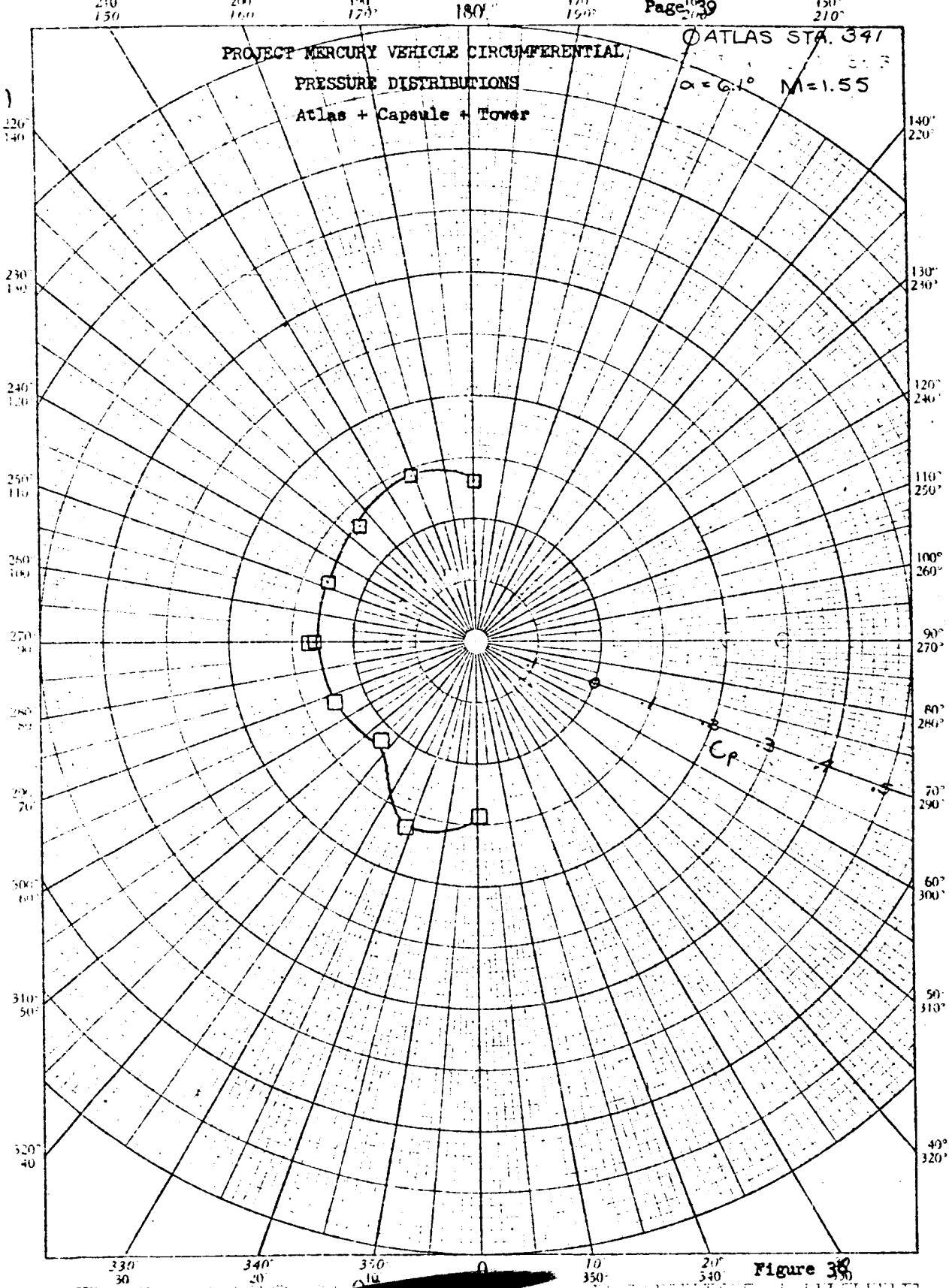


Figure 39

ATLAS STA 366
 $\alpha = 2.0^\circ$ M=1.55

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL

PRESSURE DISTRIBUTIONS

Atlas + Capsule + Tower

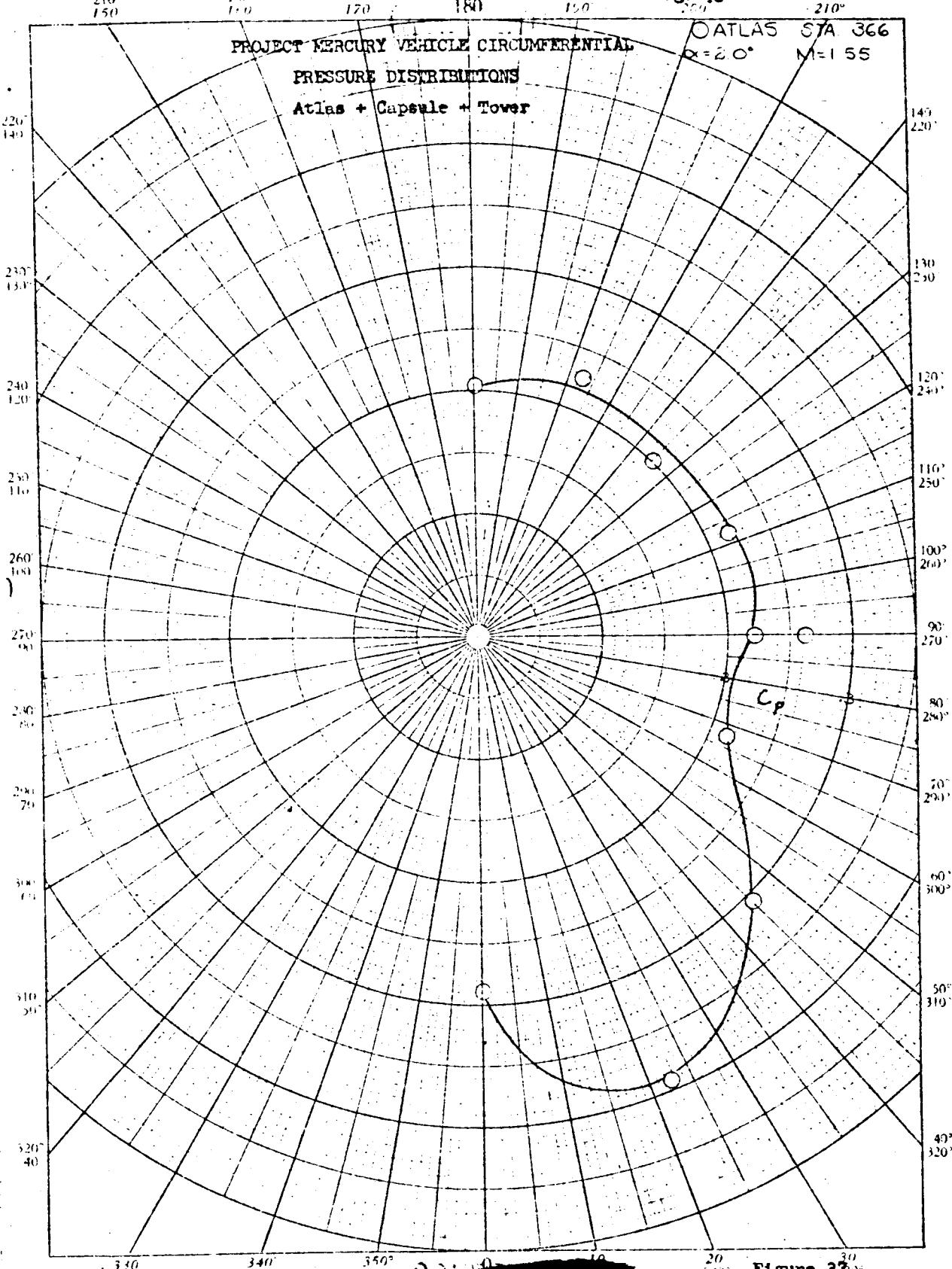


Figure 370

TN-59-0000-00304

Page 51

150° 160° 170° 180° 190° 200° 210°

ATLAS STA 366
 $\alpha = 4.1^\circ$ M = 1.55

210°
150°

200°
160°

190°
170°

180°

170°
190°

140°
220°

130°
230°

120°
240°

110°
250°

100°
260°

90°
270°

80°
280°

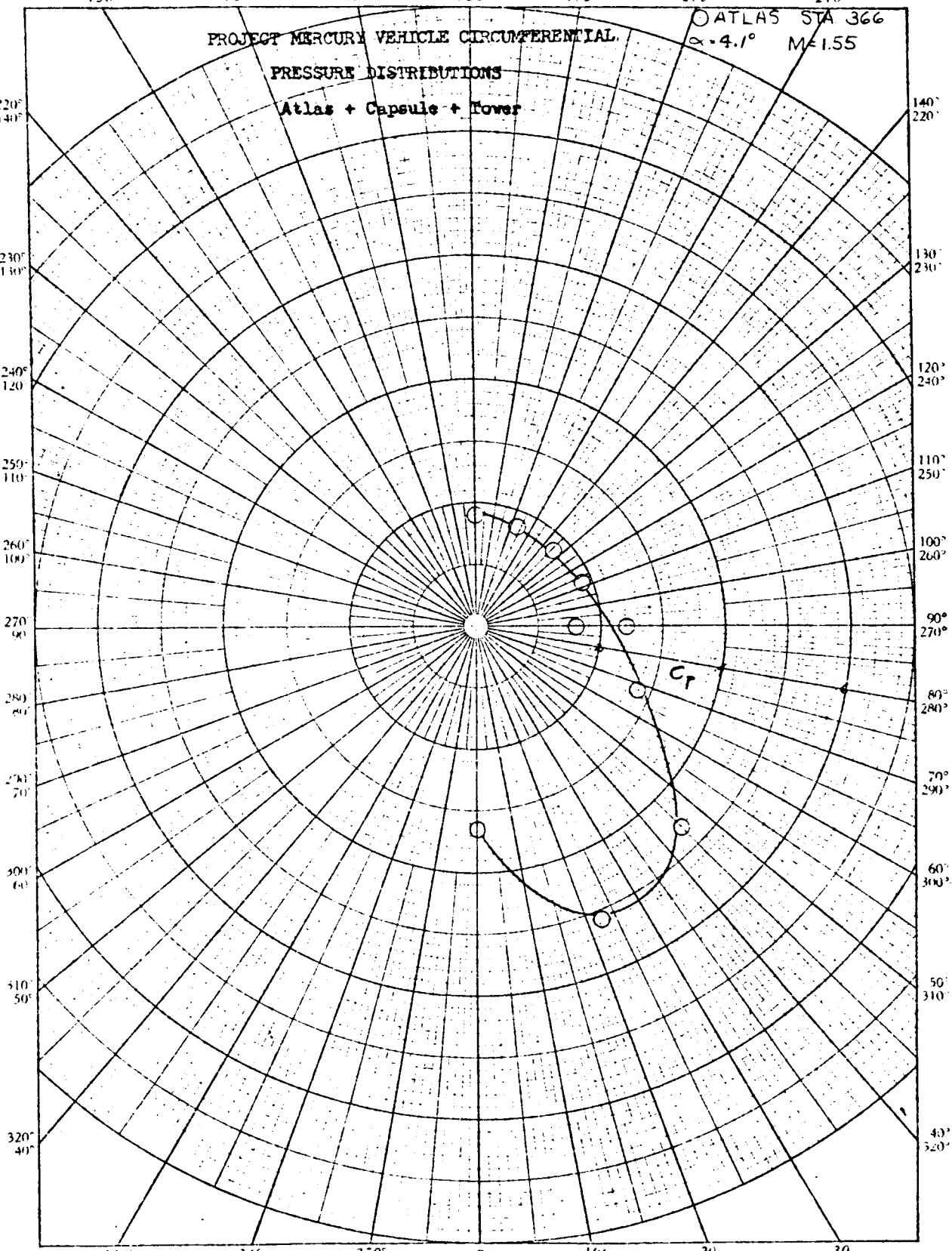
70°
290°

60°
300°

50°
310°

40°
320°

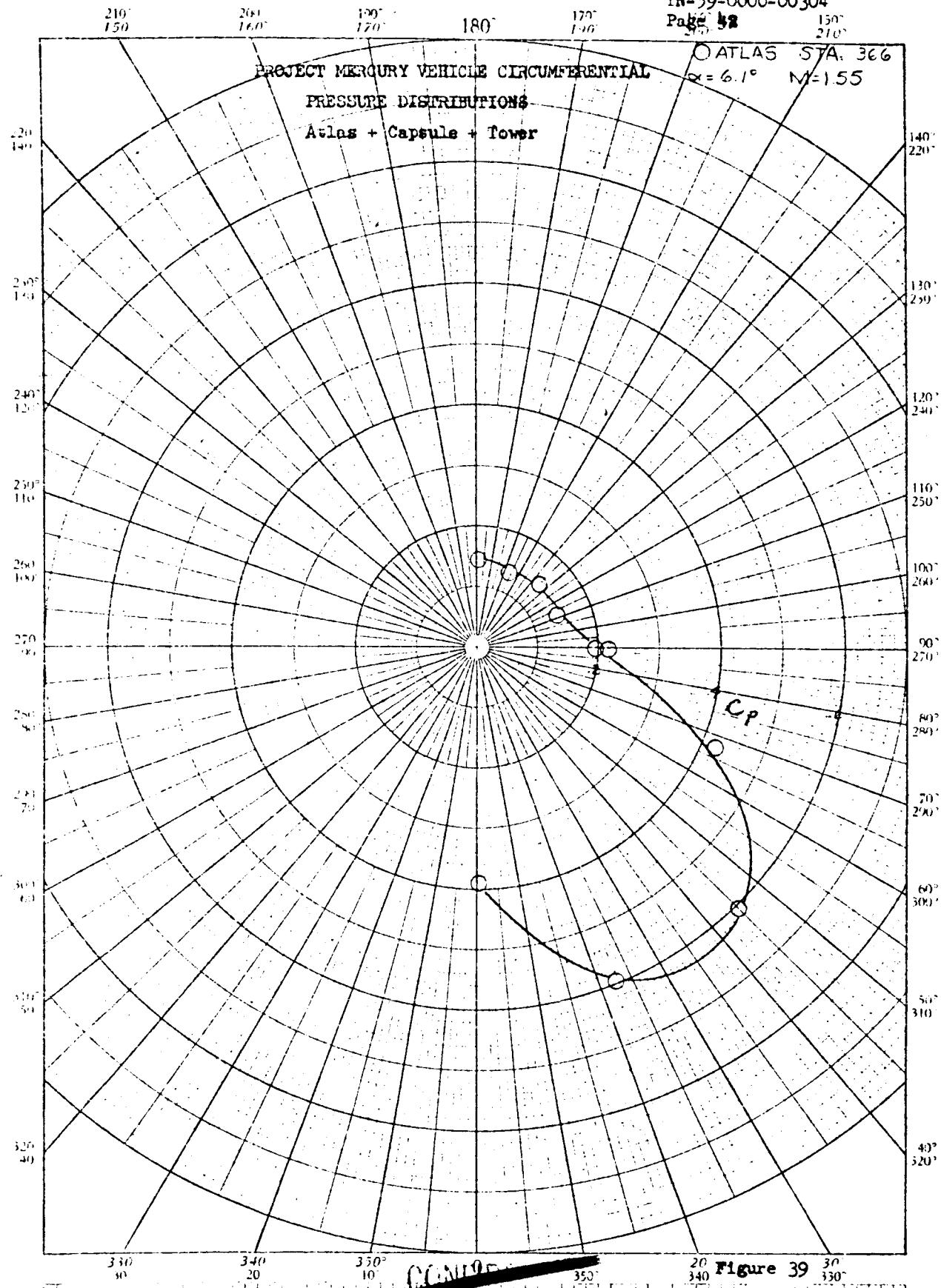
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower



POLAR CO-ORDINATE
MATERIAL ATTACHED

330° 340° 350° 360° 30° 20° 10° 0° 10° 20° 30° 340° 350°

Figure 3830



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165 Page 43

155 Page 43
260

150°
210°

1

155 Page 43
260

$$\angle = 20^\circ \quad M = 1.55$$

$$\alpha = 2.0^\circ$$

M-15

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PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS

Atlas + Capsule + Tower

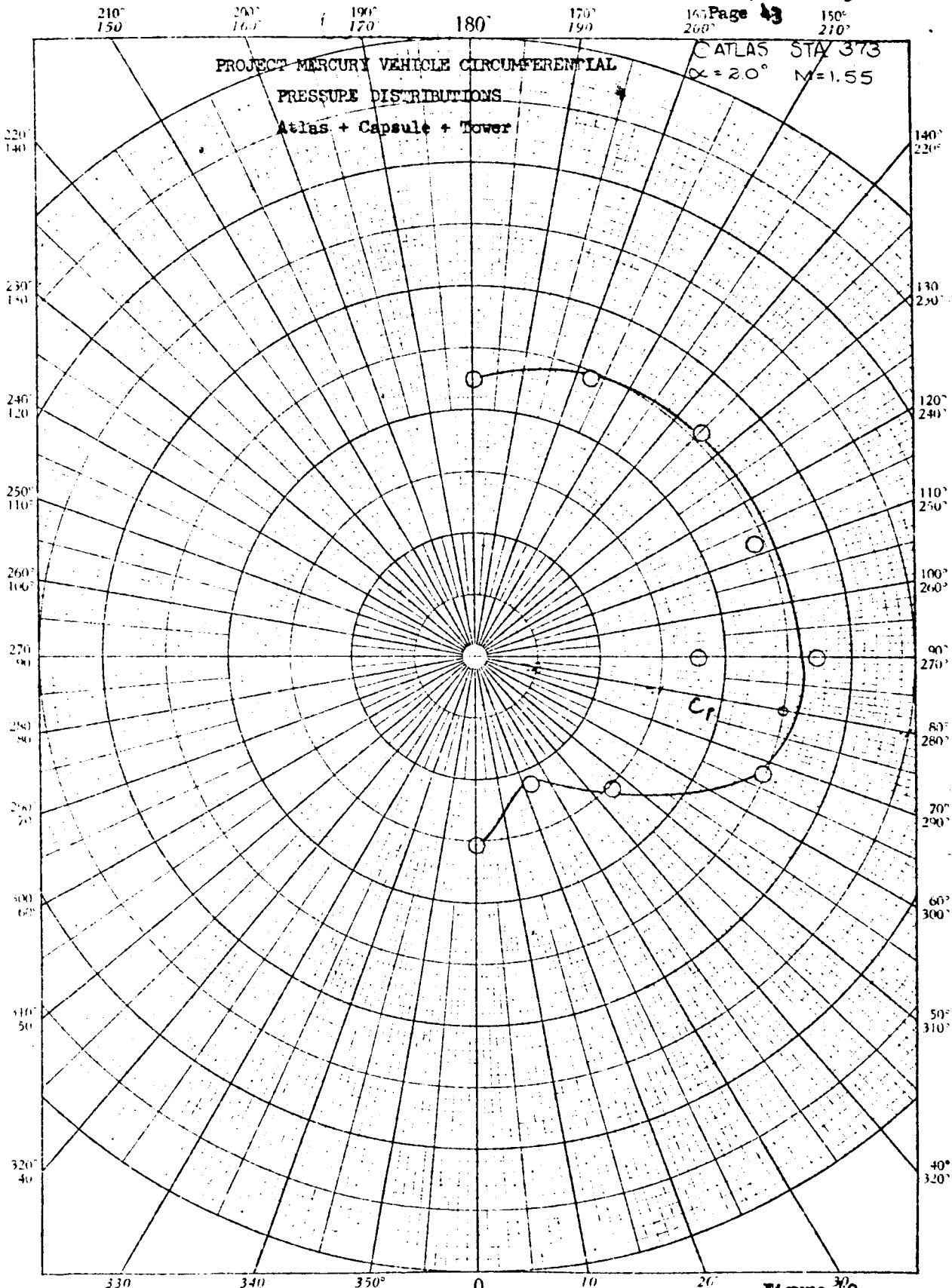


Figure 30

POLAR CO-ORDINATE SYSTEMS 359-31

ATLAS STA 373

 $\alpha = 4.1^\circ$ $M = 1.55$

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL

PRESSURE DISTRIBUTIONS

Atlas + Capsule + Tower

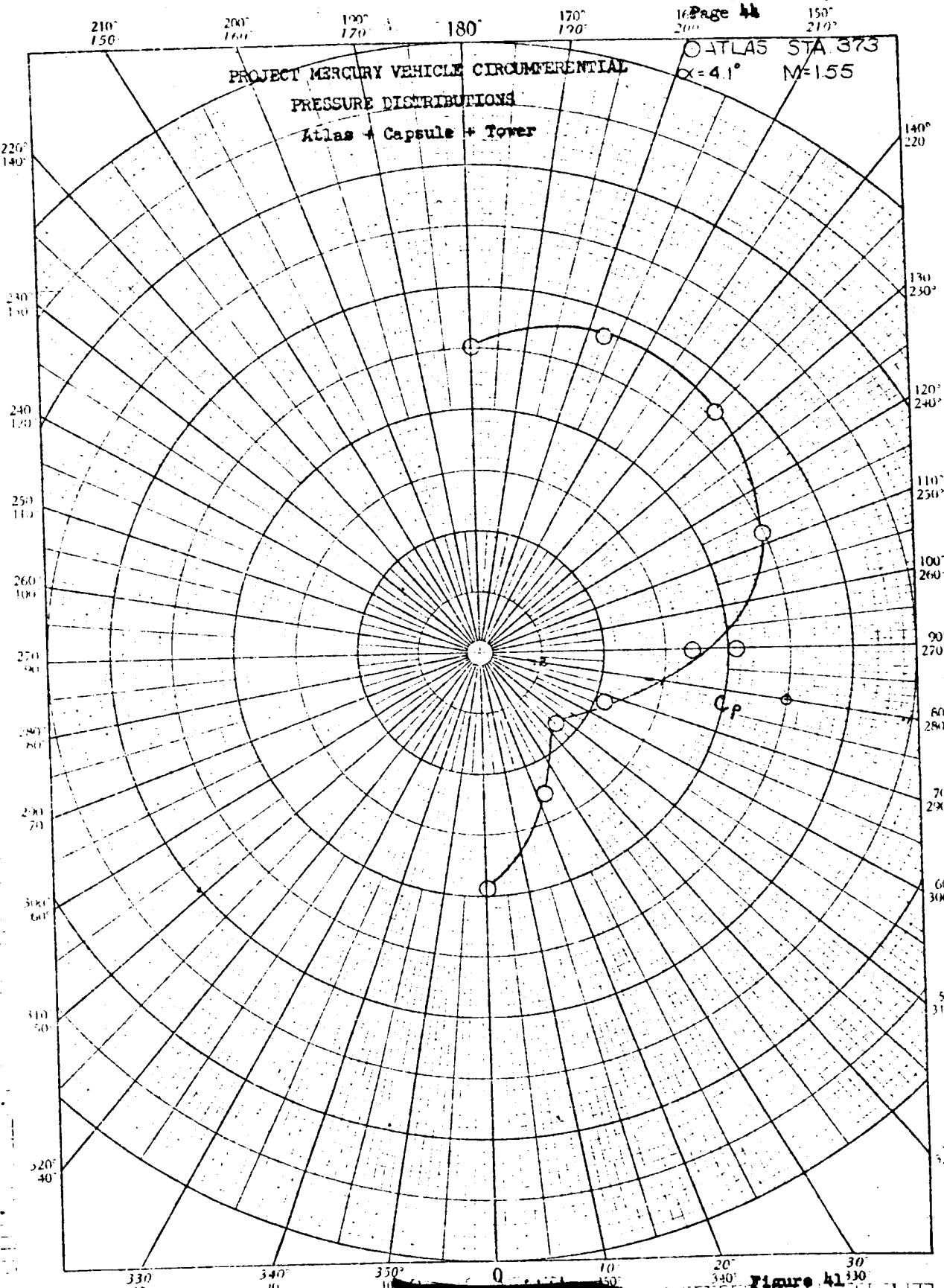
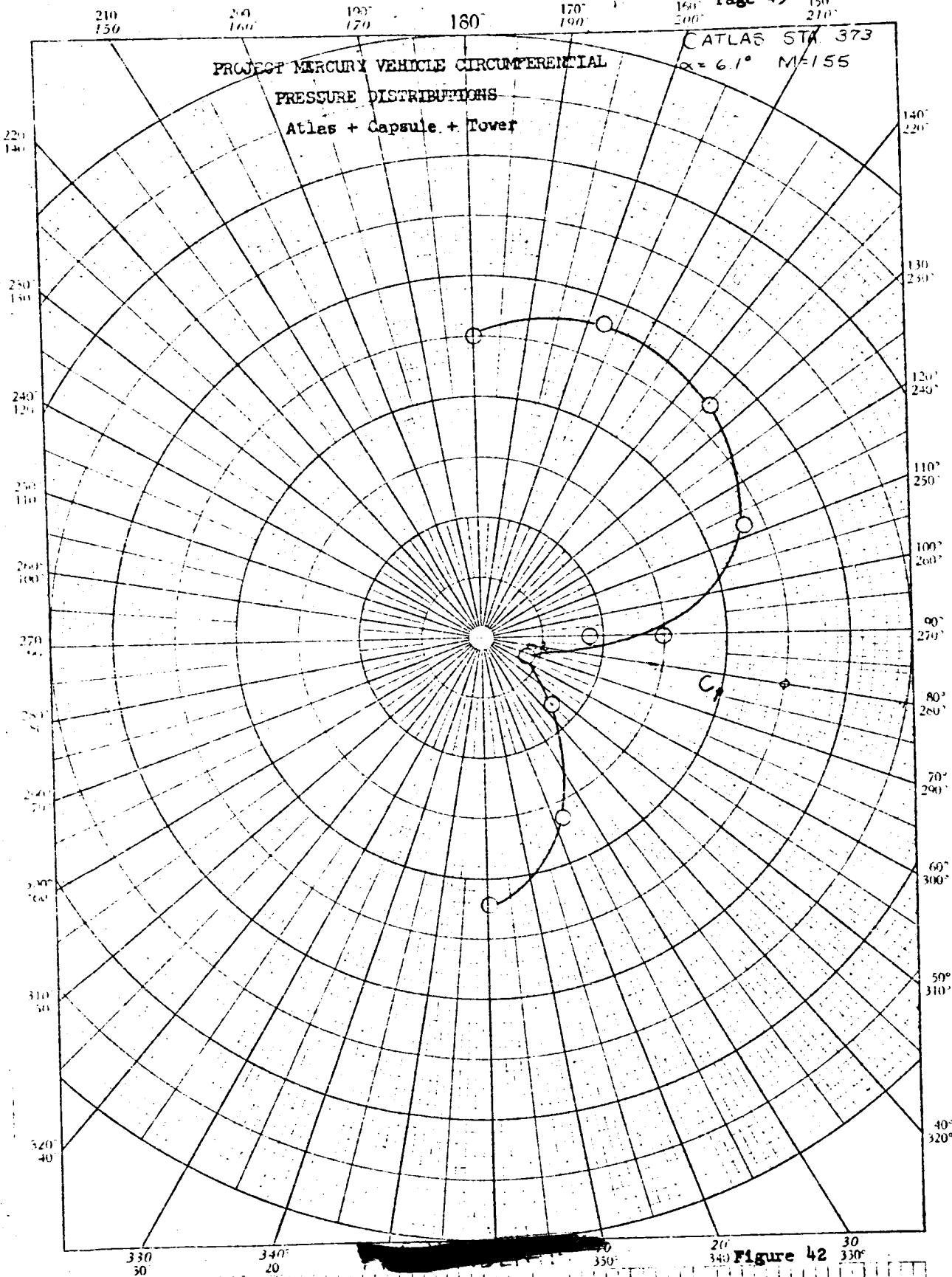


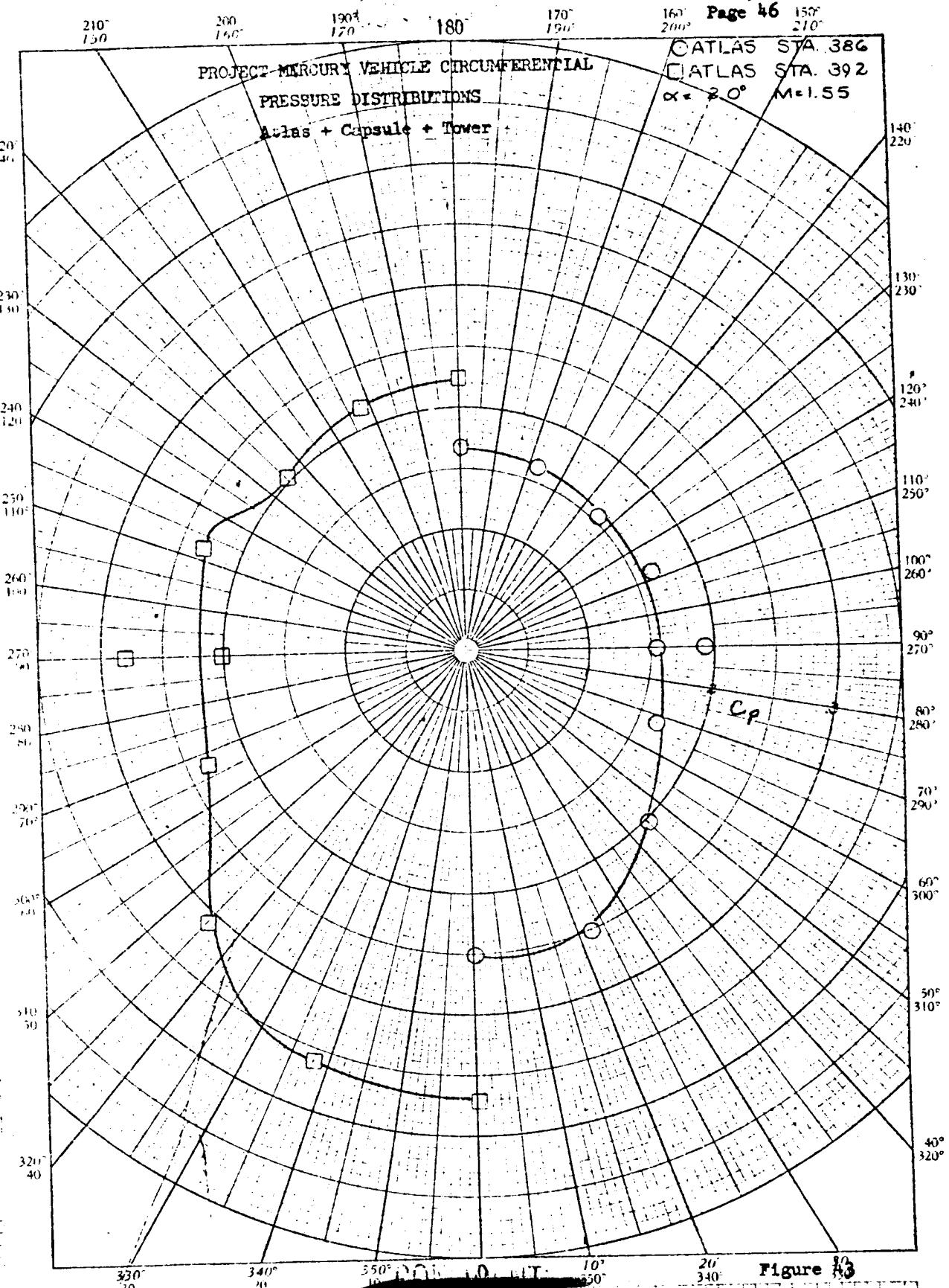
Figure 41

CATLAS STA 373

 $\alpha = 6.1^\circ$ M=1.55Polar Coordinate
Tracing Paper Co.

CATLAS STA. 386

CATLAS STA. 392

 $\alpha = 20^\circ$ $M=1.55$ 

~~ATLAS STA. 386~~
~~ATLAS STA. 392~~
 $\alpha = 4.1^\circ$ $M = 1.55$

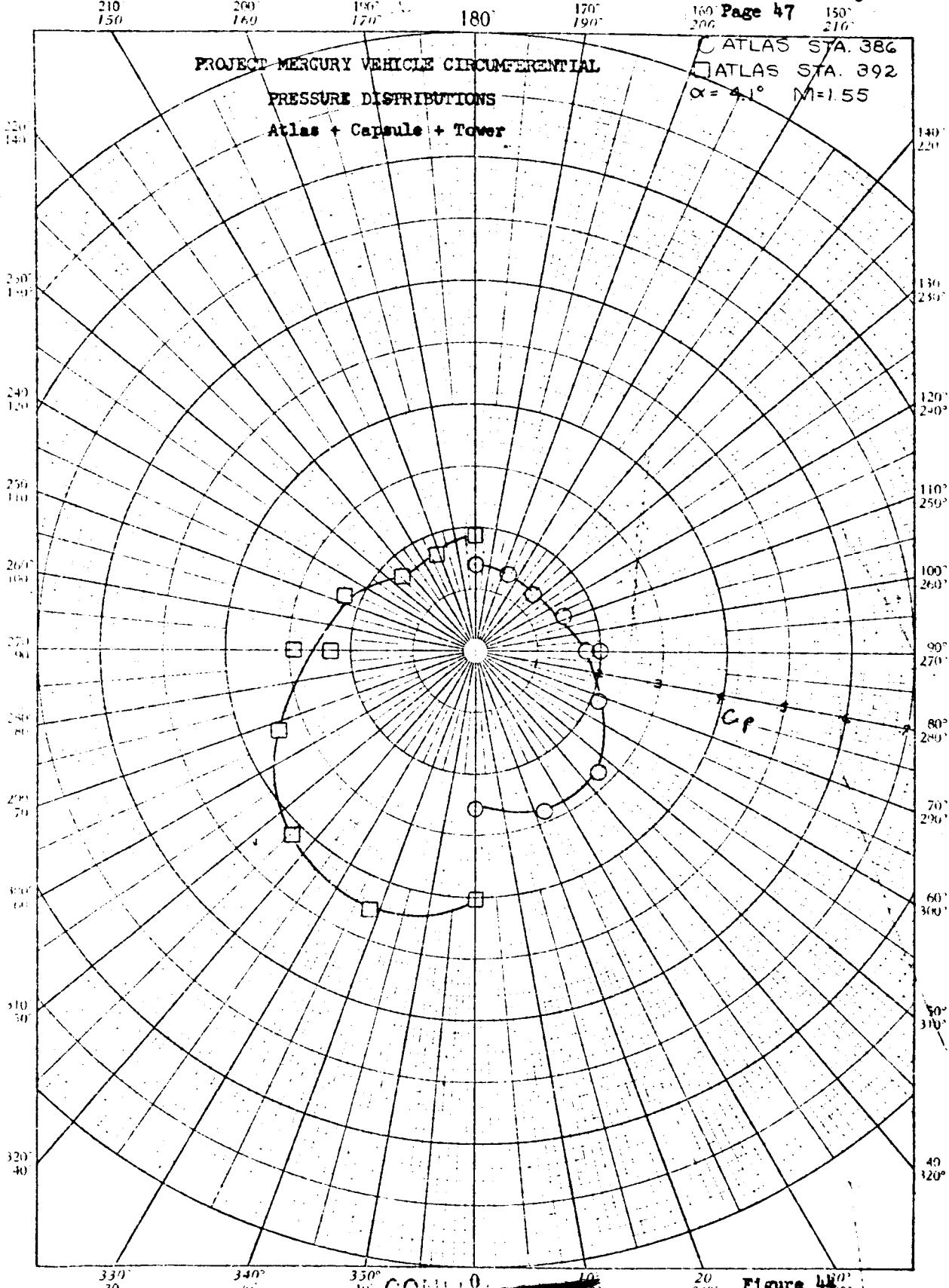


Figure 44

210
150240°
160°190°
170°

180°

170°
190°

ATLAS STA. 430
 □ ATLAS STA. 448
 $\alpha = 8.0^\circ$ $M = 1.55$

140°

220°

240°

260°

280°

300°

320°

340°

360°

380°

400°

420°

440°

460°

480°

500°

520°

540°

560°

580°

600°

640°

680°

720°

760°

800°

840°

880°

920°

960°

1000°

1040°

1080°

1120°

1160°

1200°

1240°

1280°

1320°

1360°

1400°

1440°

1480°

1520°

1560°

1600°

1640°

1680°

1720°

1760°

1800°

1840°

1880°

1920°

1960°

2000°

2040°

2080°

2120°

2160°

2200°

2240°

2280°

2320°

2360°

2400°

2440°

2480°

2520°

2560°

2600°

2640°

2680°

2720°

2760°

2800°

2840°

2880°

2920°

2960°

3000°

3040°

3080°

3120°

3160°

3200°

3240°

3280°

3320°

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3960°

4000°

4040°

4080°

4120°

4160°

4200°

4240°

4280°

4320°

4360°

4400°

4440°

4480°

4520°

4560°

4600°

4640°

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4720°

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4800°

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5320°

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5480°

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5800°

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5880°

5920°

5960°

6000°

6040°

6080°

6120°

6160°

6200°

6240°

6280°

6320°

6360°

6400°

6440°

6480°

6520°

6560°

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6720°

6760°

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6840°

6880°

6920°

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7000°

7040°

7080°

7120°

7160°

7200°

7240°

7280°

7320°

7360°

7400°

7440°

7480°

7520°

7560°

7600°

7640°

7680°

7720°

7760°

7800°

7840°

7880°

7920°

7960°

8000°

8040°

8080°

8120°

8160°

8200°

8240°

8280°

8320°

8360°

8400°

8440°

8480°

8520°

8560°

8600°

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8680°

8720°

8760°

8800°

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8880°

8920°

8960°

9000°

9040°

9080°

9120°

9160°

9200°

9240°

9280°

9320°

9360°

9400°

9440°

9480°

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9840°

9880°

9920°

9960°

10000°

10040°

10080°

10120°

10160°

10200°

10240°

10280°

10320°

10360°

10400°

10440°

10480°

10520°

10560°

10600°

10640°

10680°

10720°

10760°

10800°

10840°

10880°

10920°

10960°

11000°

11040°

11080°

11120°

11160°

11200°

11240°

11280°

11320°

11360°

11400°

11440°

11480°

11520°

11560°

11600°

11640°

11680°

11720°

11760°

11800°

11840°

11880°

11920°

11960°

12000°

12040°

12080°

12120°

12160°

12200°

12240°

12280°

12320°

12360°

12400°

12440°

12480°

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower

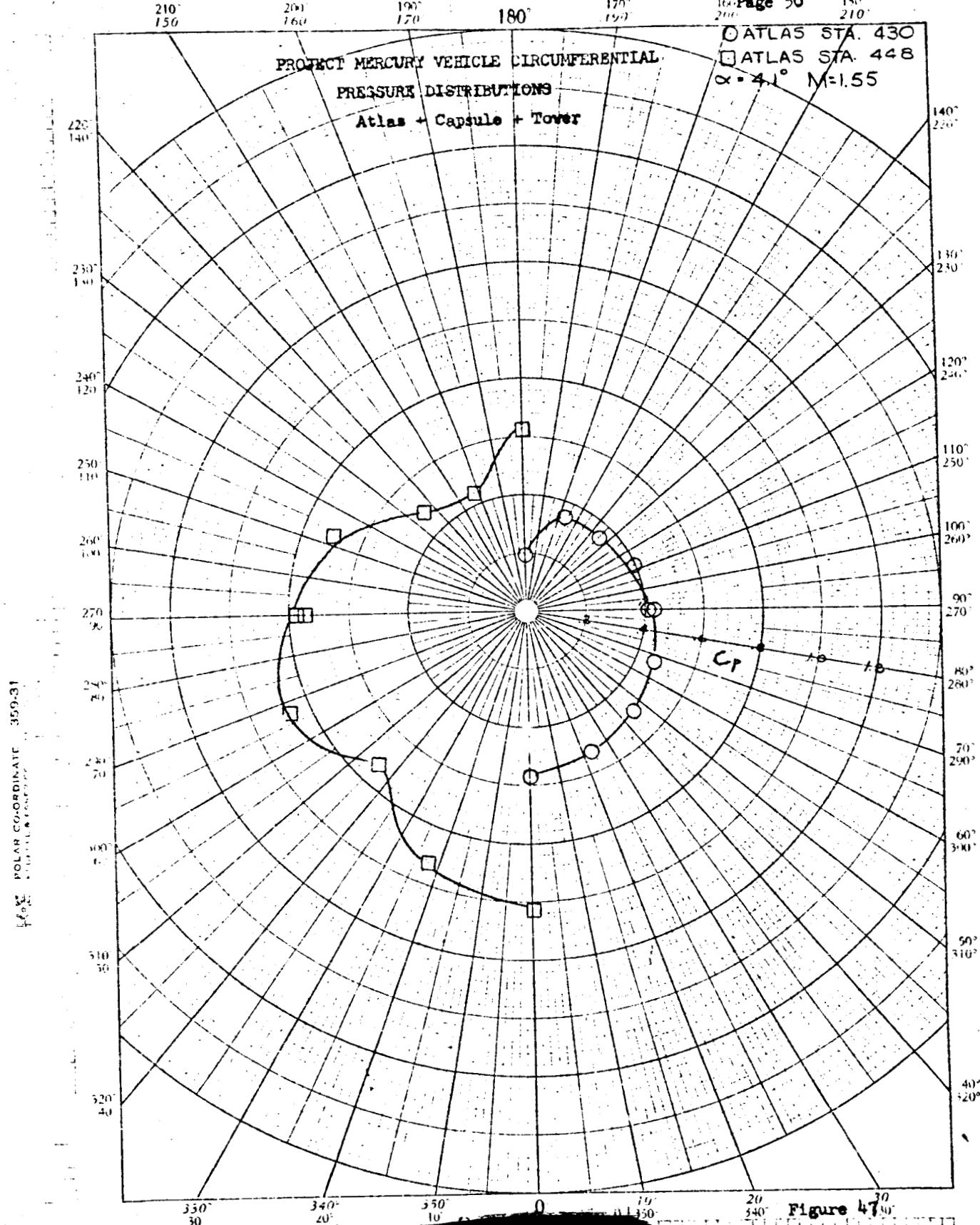
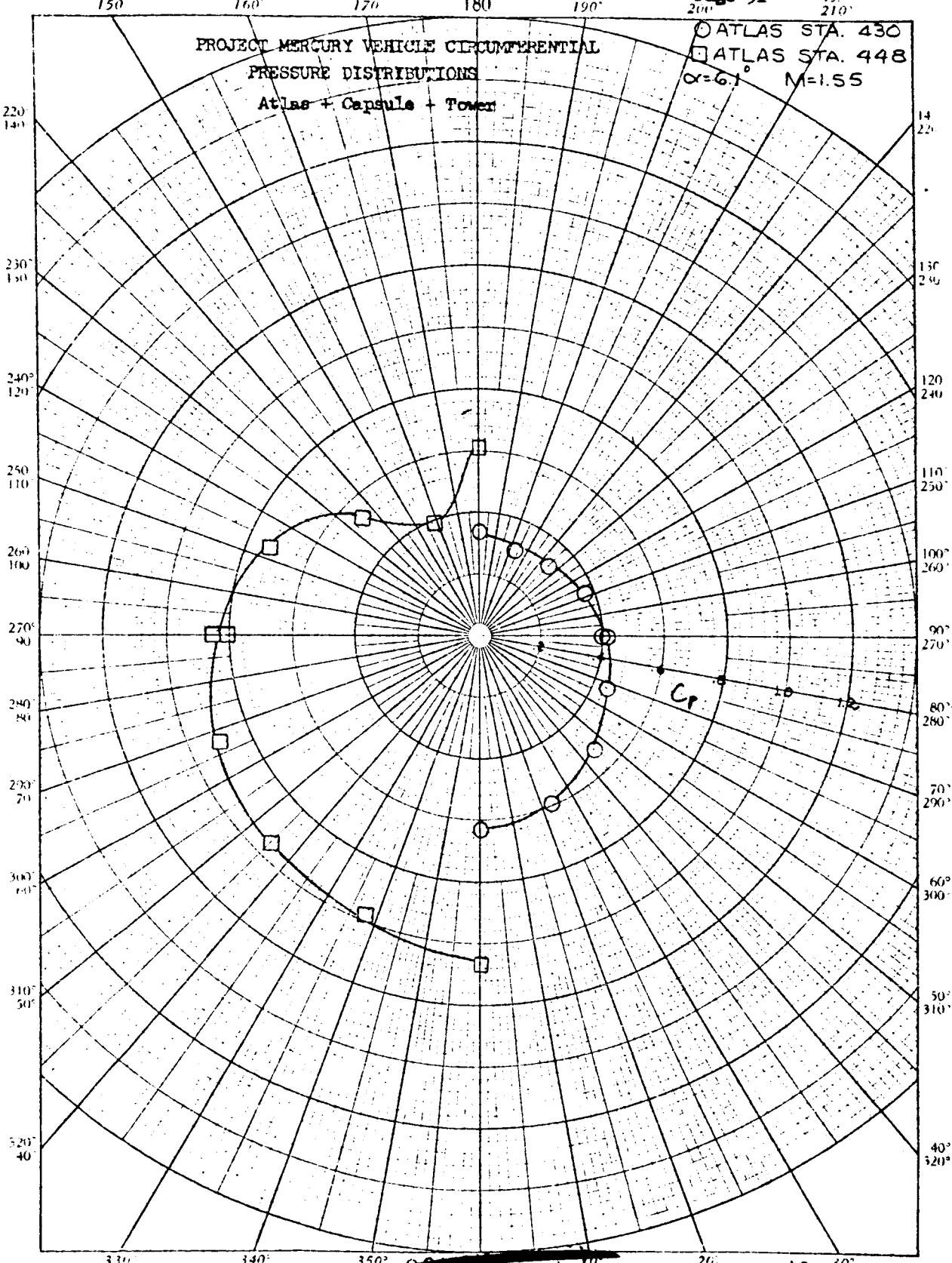


Figure 47

210°
150°
200°
160°
170°
180°
190°
170°
190°

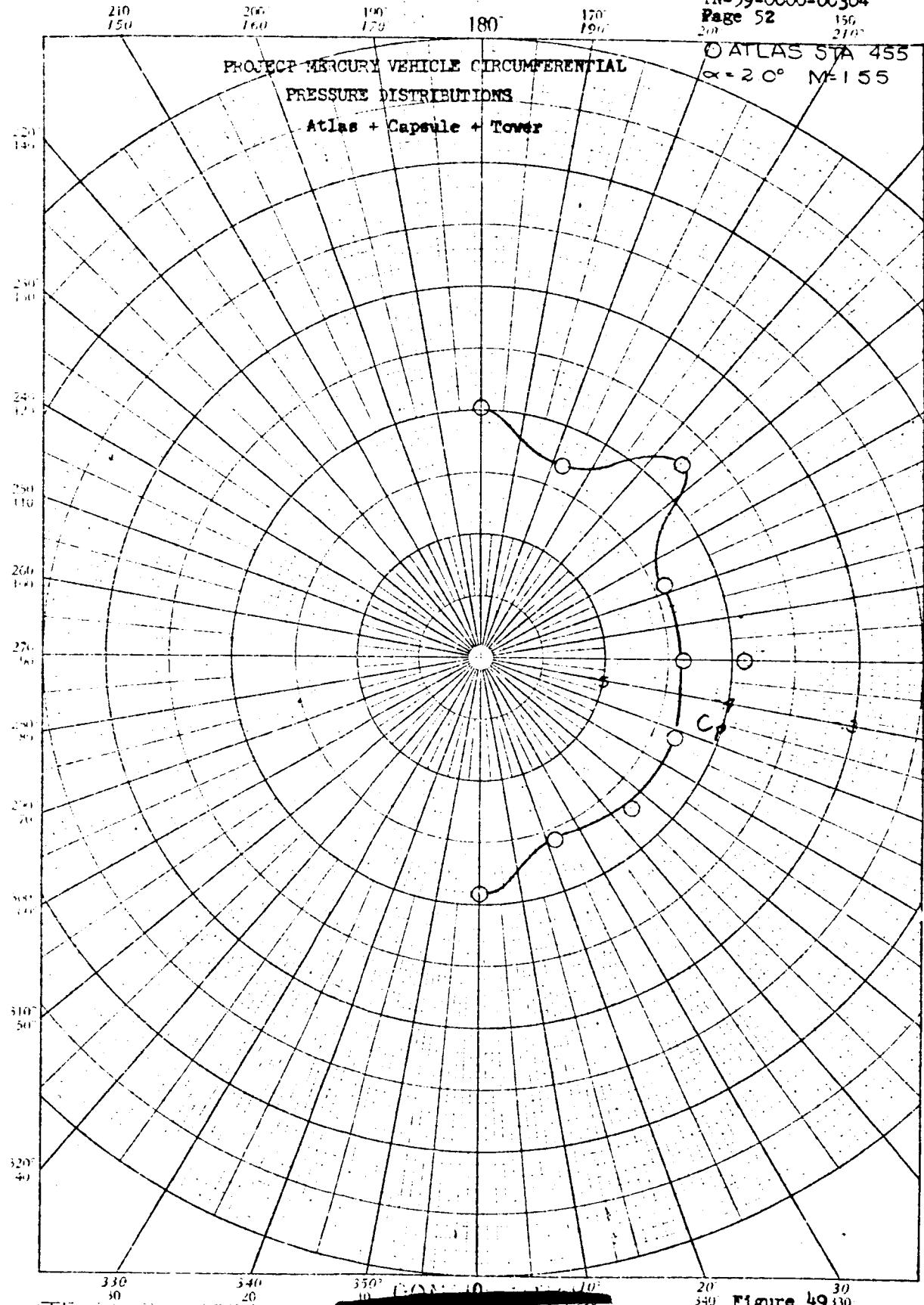
PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower

○ ATLAS STA. 430
□ ATLAS STA. 448
 $\alpha = 6.7^\circ$
 $M = 1.55$



O ATLAS STA 455
 $\alpha = 20^\circ$ M-155PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS

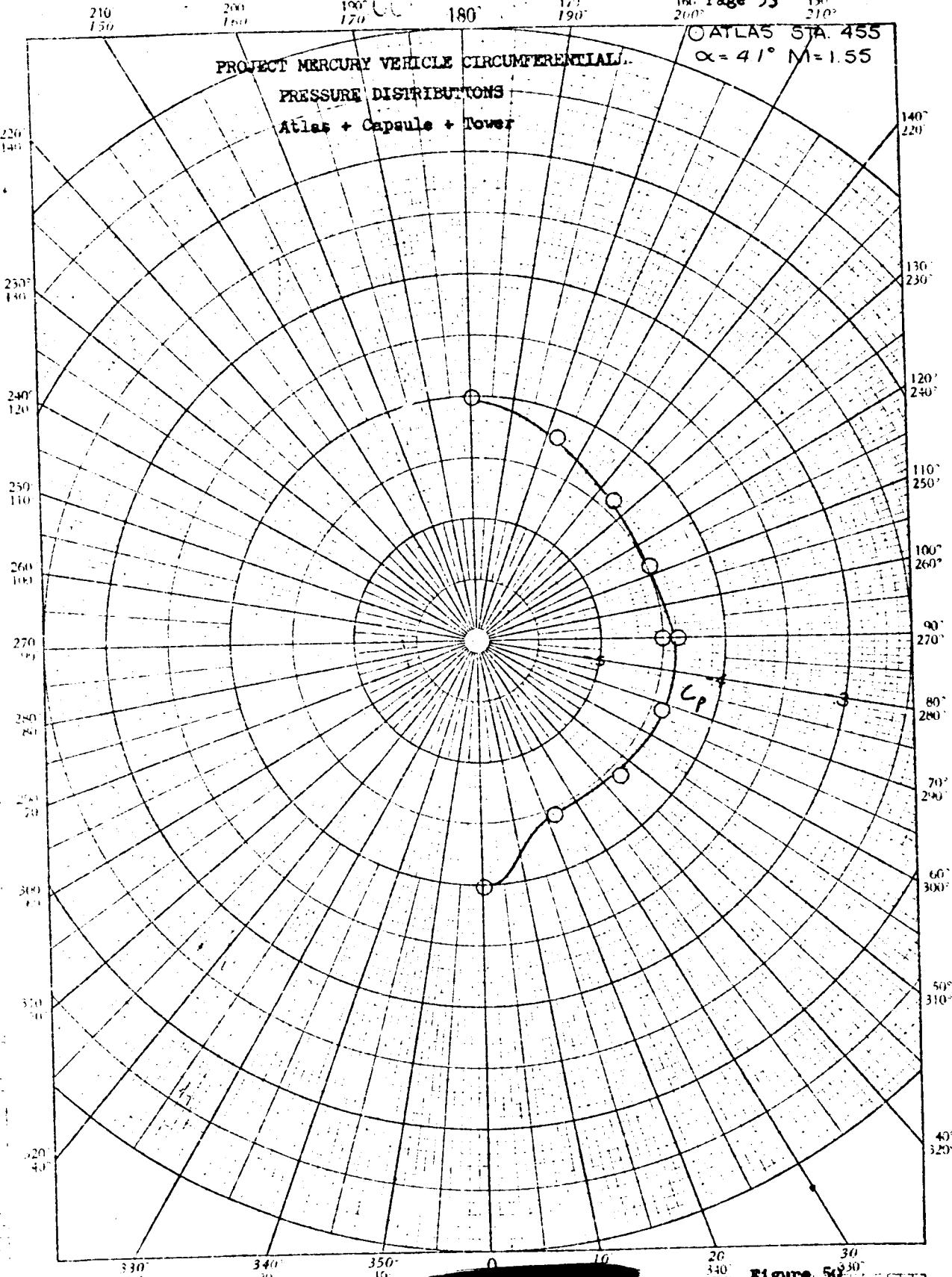
Atlas + Capsule + Tower

POLAR CO-ORDINATE
PREDICTION

THE UNITED STATES GOVERNMENT OWNED

Figure 49

ATLAS STA. 455

 $\alpha = 41^\circ \quad M = 1.55$ 

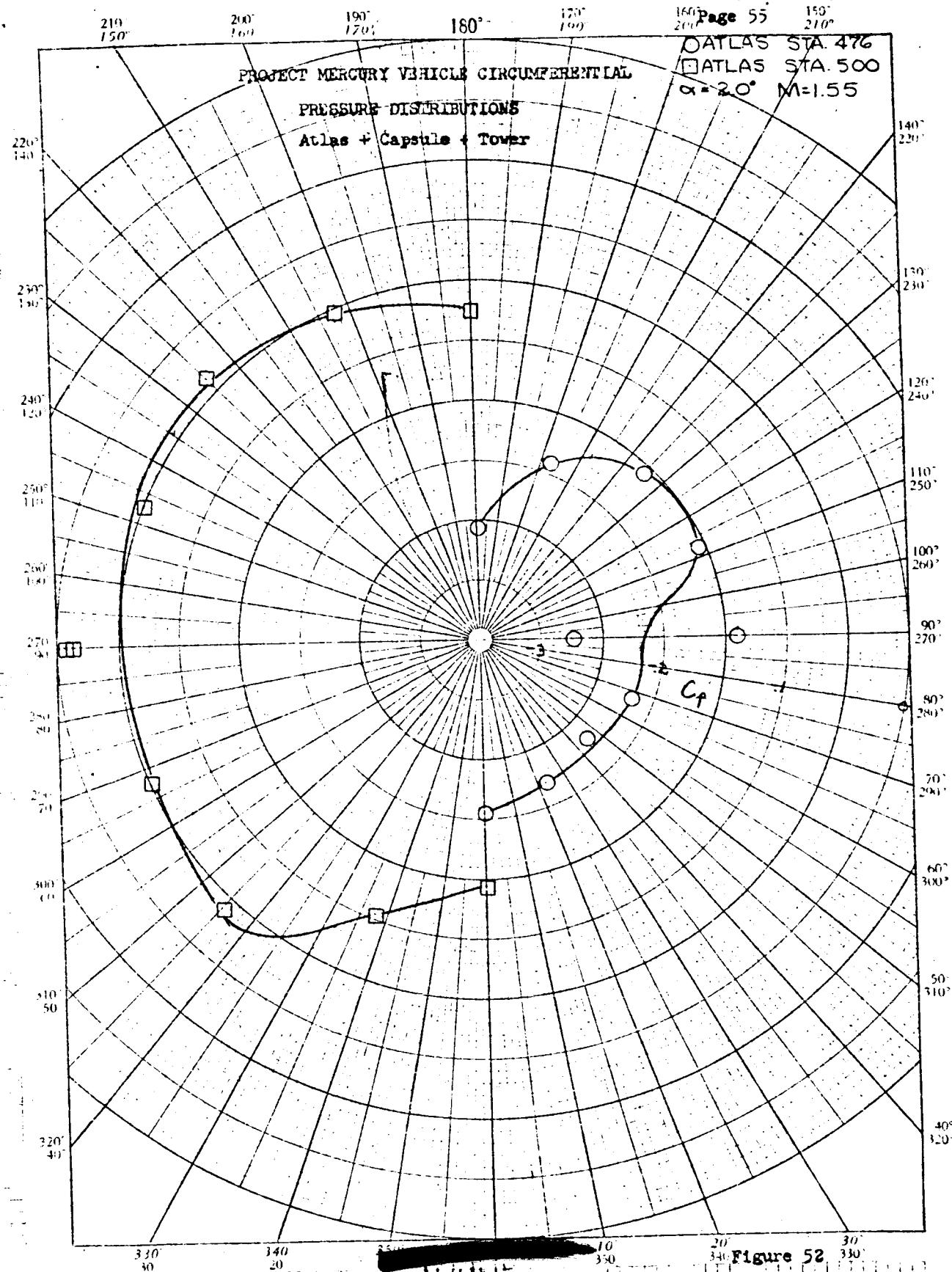
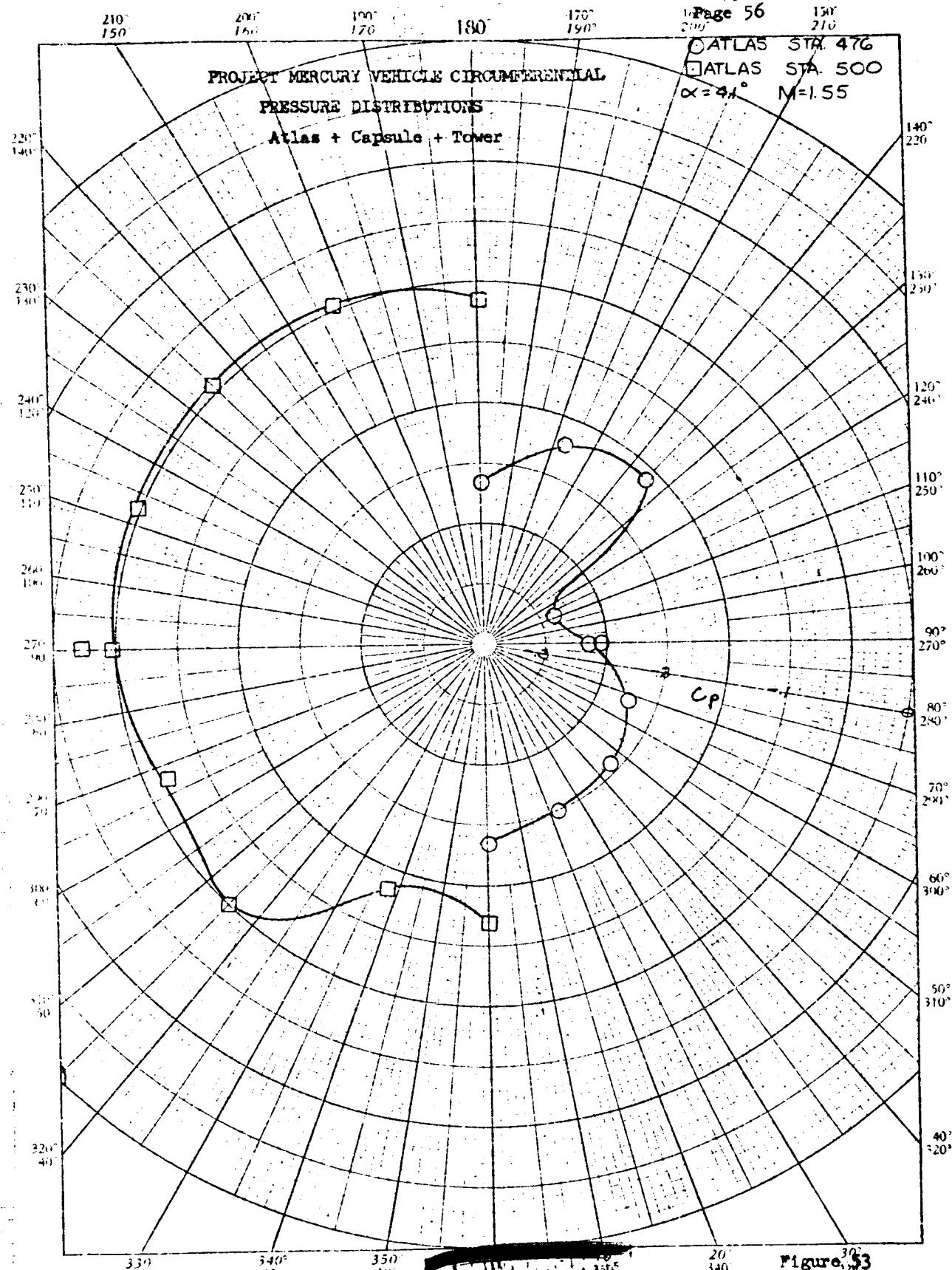


FIG. 52 POLAR COORDINATE 350 31

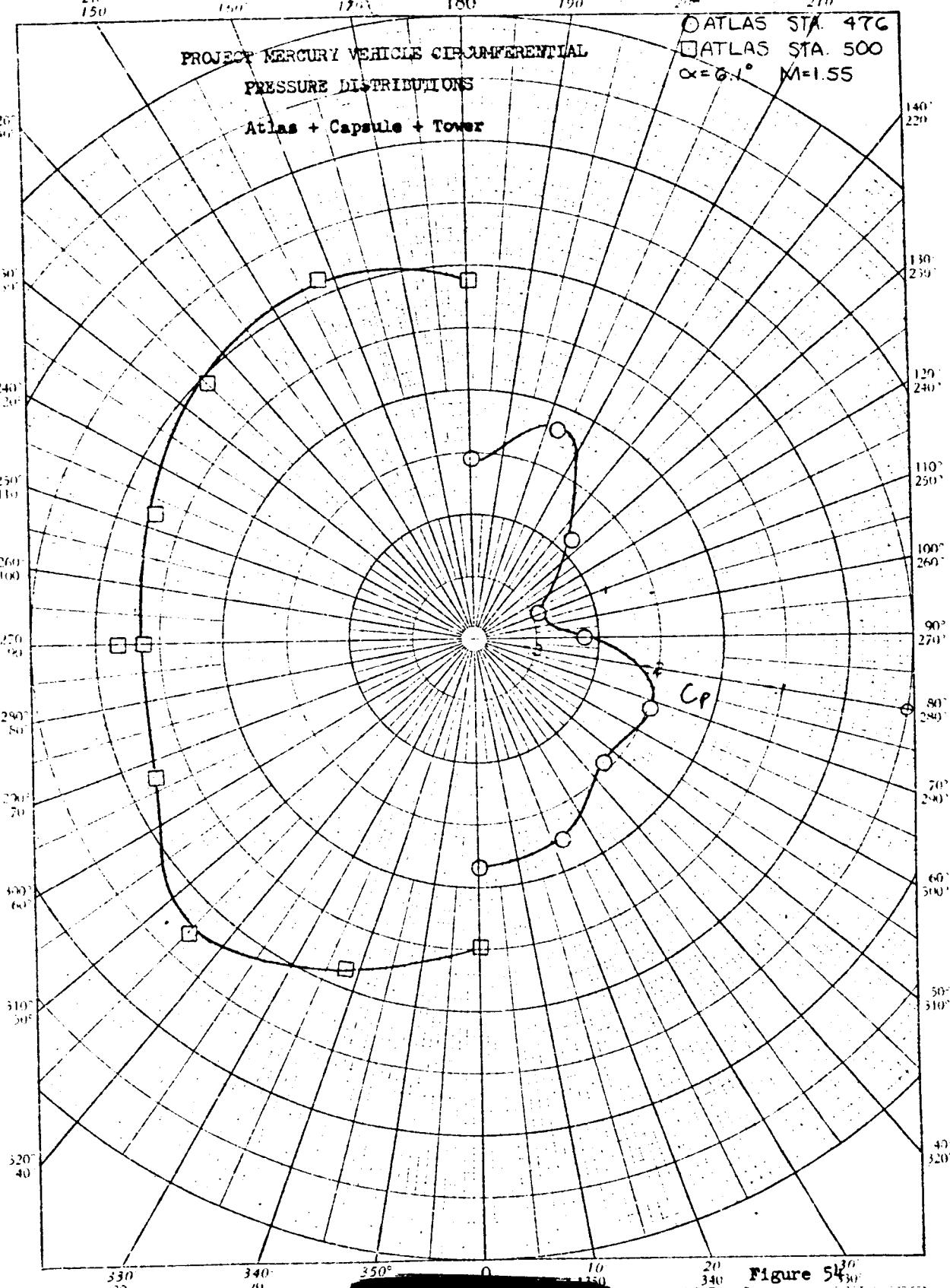
Figure 52

ATLAS STA. 476
ATLAS STA. 500
 $\alpha = 41^\circ$
 $M = 1.55$



ATLAS STA. 476
 ATLAS STA. 500
 $\alpha = 6.1^\circ$ $M = 1.55$

POLAR COORDINATE 355-31
 SURFACE PRESSURE

Figure 54³⁶₃₀

210°
150°200°
160°190°
170°

180°

170°
190°

200°

150°
210°

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower

ATLAS STA. 513
ATLAS STA. 580
 $\alpha = 3.0^\circ$ $M = 1.55$

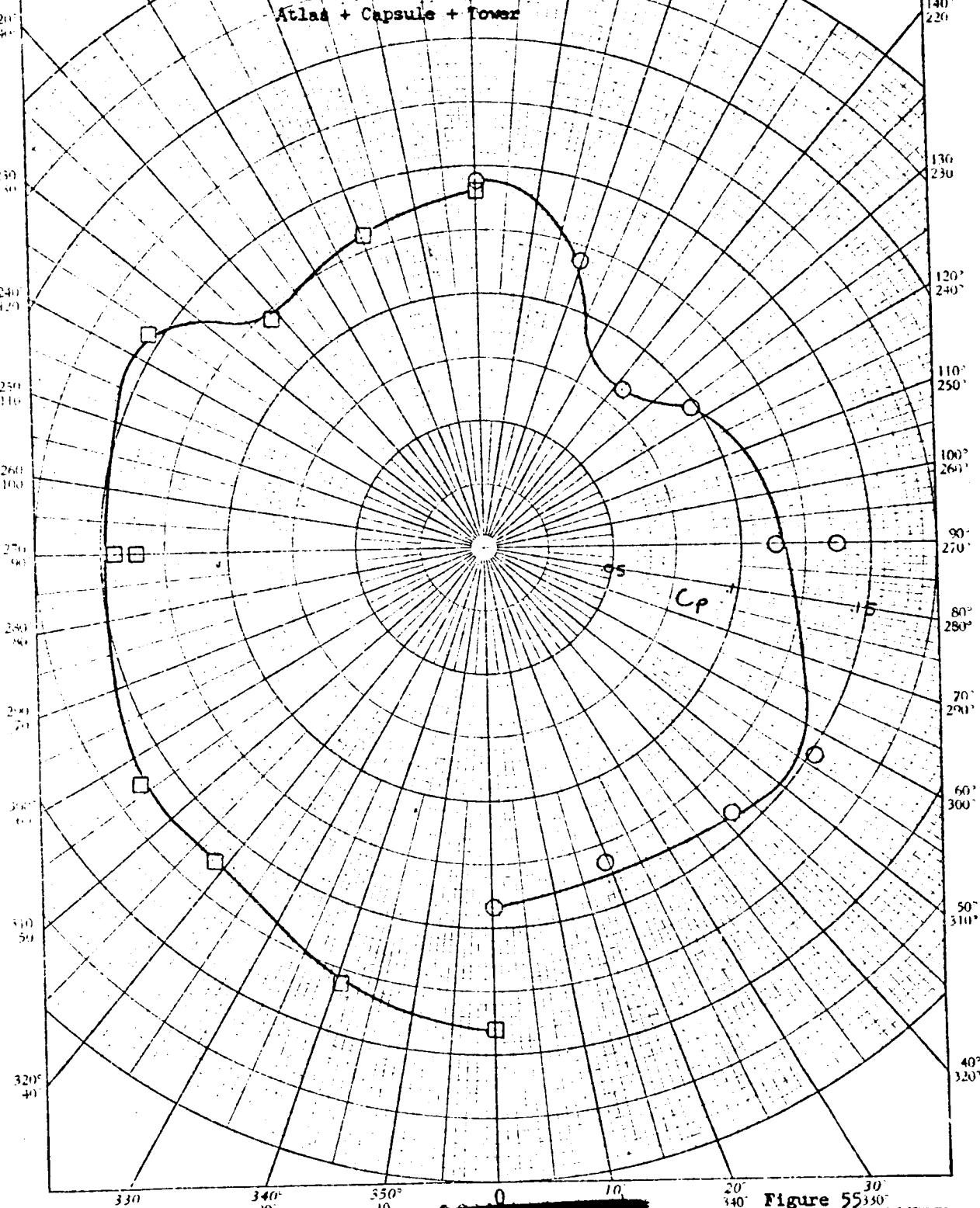


Figure 55307

CATLAS STA 513

ATLAS STA 580

 $\alpha = 41^\circ$ $M = 1.55$

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL

PRESSURE DISTRIBUTIONS

Atlas + Capsule + Tower

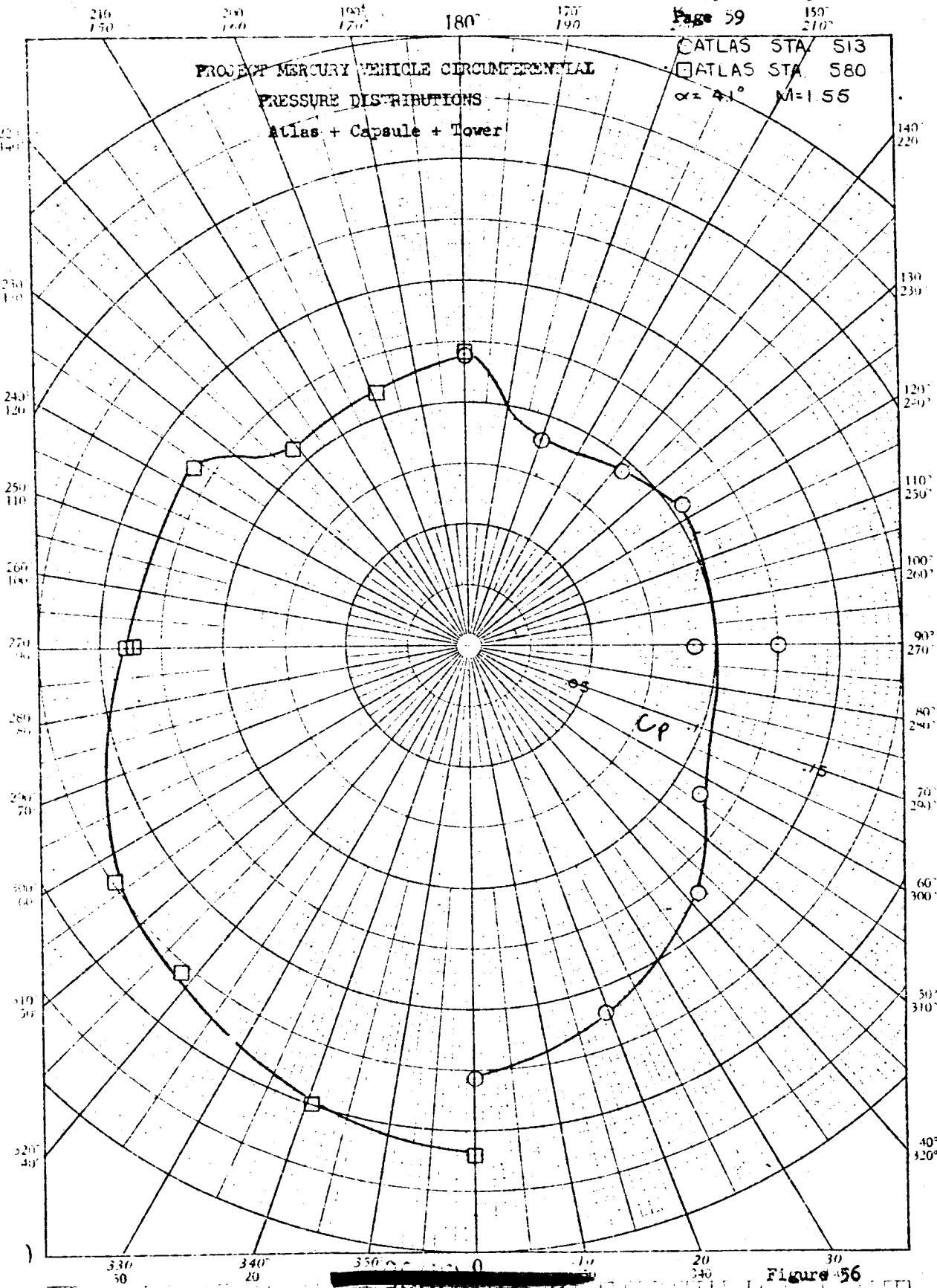
POLAR COORDINATE
MILLIBARS PER SQ INCH

Figure 56

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~~CATTAS STA. 5~~

ATLAS STA 5

~~ATLAS~~ Sy. 3
SIX 1° MA-LEE

$$\alpha = 6^\circ \quad n = 1.55$$

i X

PROJECT MERCURY VEHICLE CIRCUMFERENTIAL
PRESSURE DISTRIBUTIONS
Atlas + Capsule + Tower



POLAR COORDINATES 3539.31

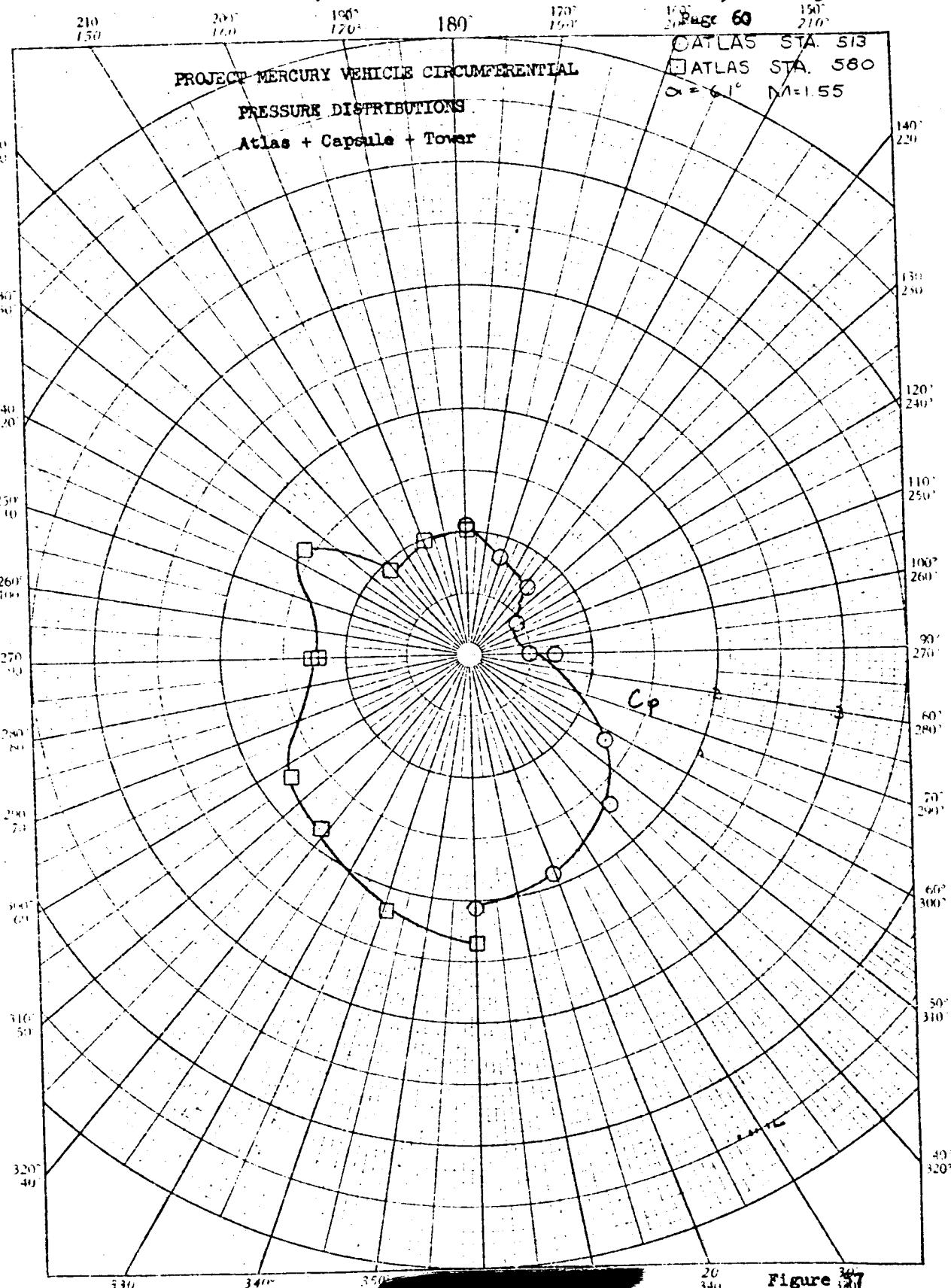


Figure 3.17

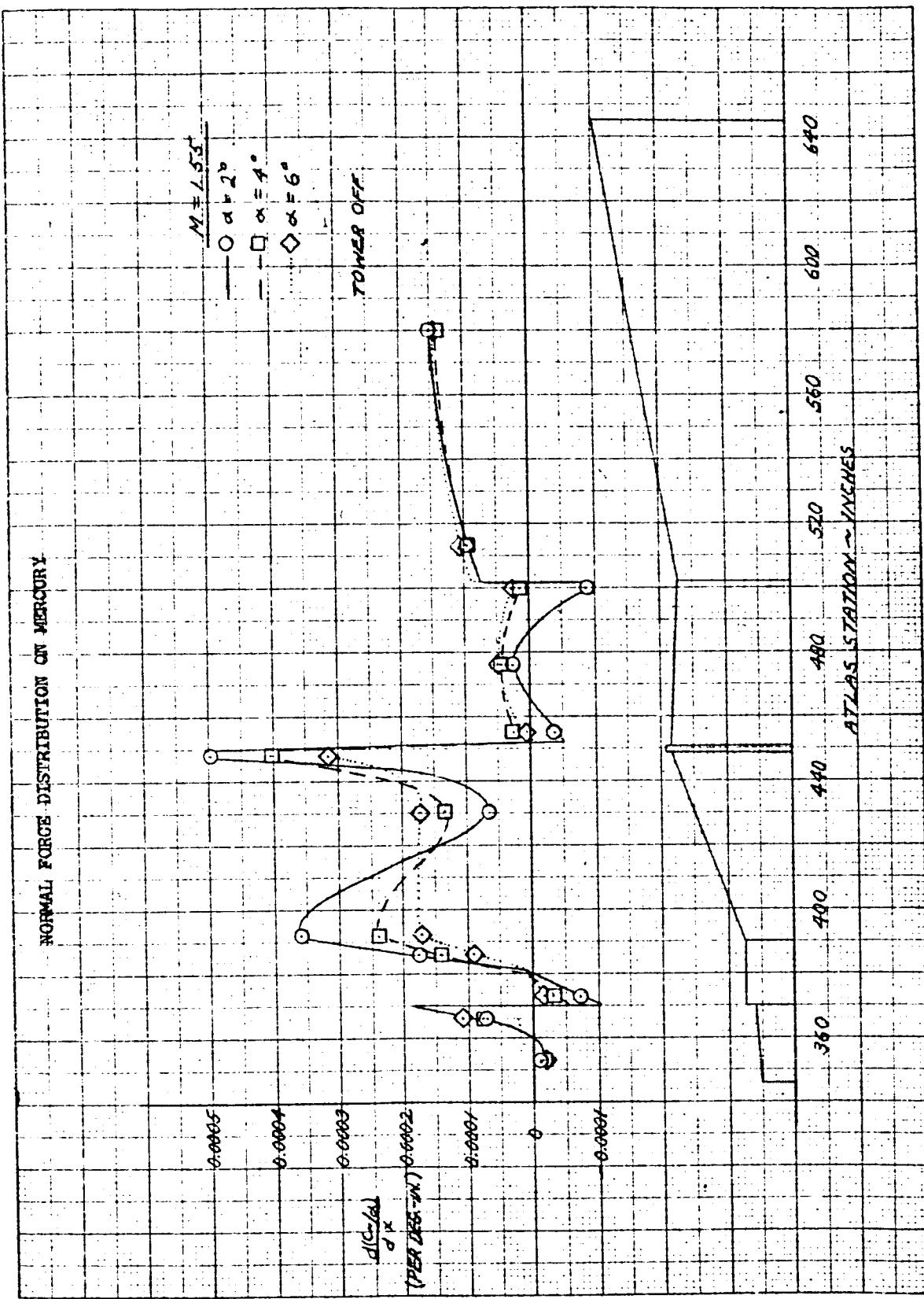


Figure 58

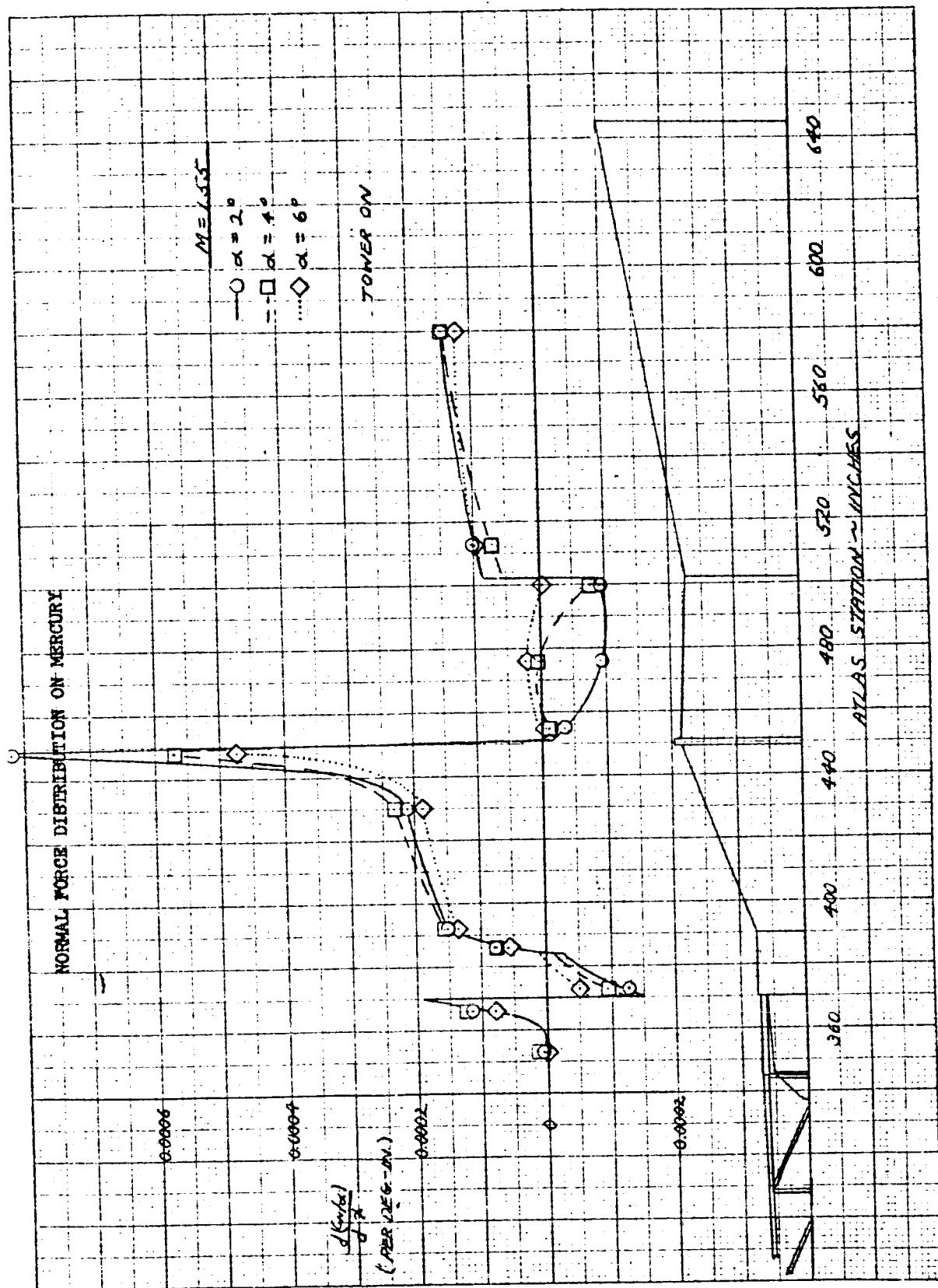


Figure 59

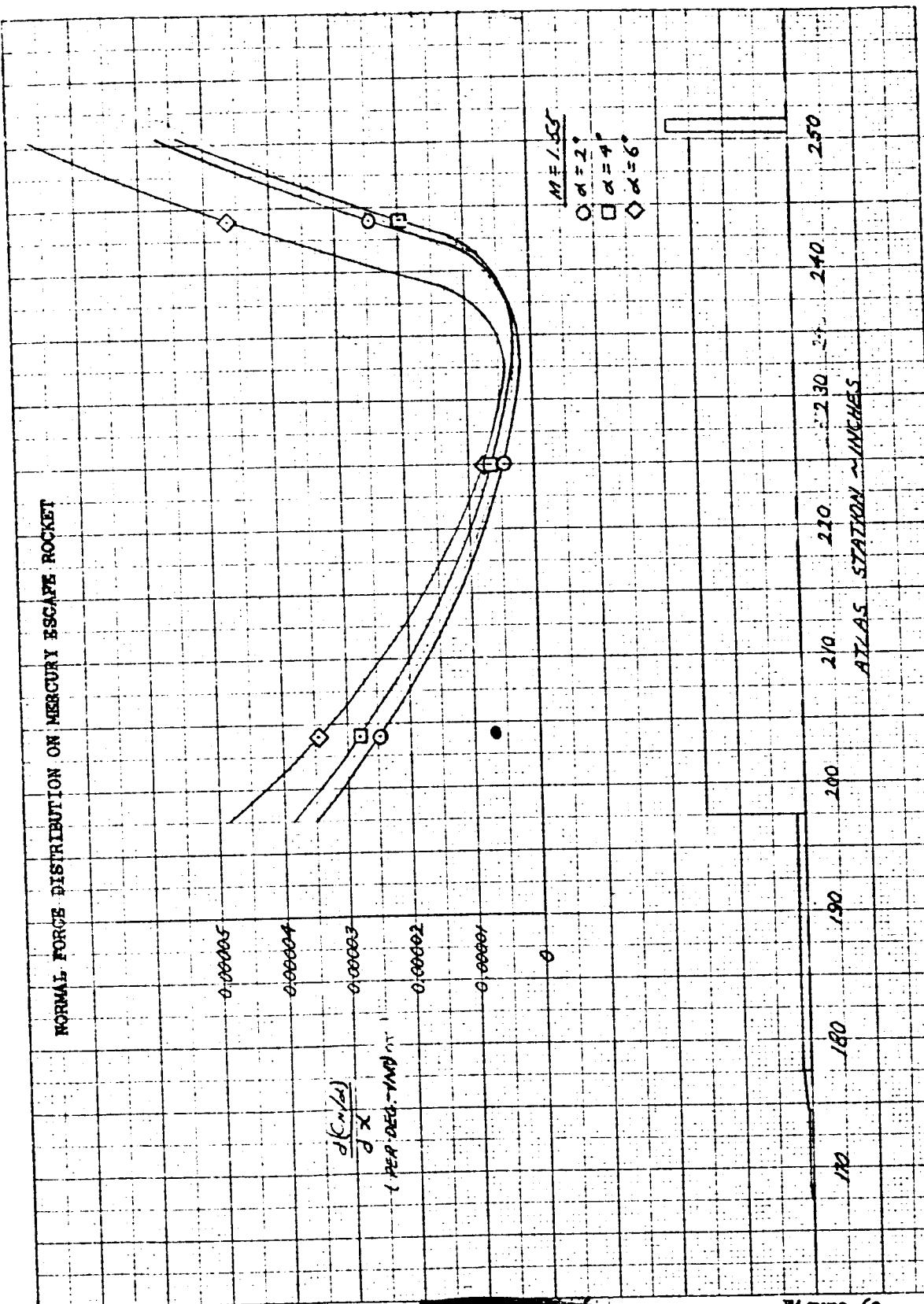


Figure 60

CONFIDENTIAL